VOL. III NO. 5

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

S·A·E

NOVEMBER 1918

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

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SOCIETY TO HOLD MEETING IN JANUARY

ALTHOUGH in stress of war all things at times seem subject to revision, not much thought is required to make clear the wisdom of the Society holding a winter meeting. The Council has been giving attention to the matter for some time, particularly the place and nature of the meeting in view of the state of war and the discontinuance in 1919 of the national automobile shows.

The Council, including Chairman Beecroft of the Meetings Committee, is practically unanimously in favor of holding a two-day meeting of the Society, consisting of technical sessions devoted to war and post-war subjects, routine and other business being reduced to a timely minimum.

The sister engineering societies of the S. A. E. will hold meetings this winter. In fact, some of them have already held strikingly successful sessions.

The days and place of the S. A. E. 1919 Winter Meeting, to be held in January, will be announced shortly. As to the time, a thorough-going effort will be made to have this synchronize with some other important event. The place will be determined on the basis of the balance of advantages as between minimum of travel involved for the members as a whole and other desirable features. The former consideration undoubtedly has much weight, from the standpoints of time, money and congestion of travel. The present choice is between Cleveland and New York.

It is the intention that a dinner will be held, in the form of a simple repast to which the members have been or are accustomed, appealing to the sense of patriotism proper at this time.

There is no doubt that much real good can be accomplished by having a war-work meeting, and the members are urged to plan to participate in some rousing sessions. The very generally and highly appreciated "punch" of the Dayton meeting in June will not be missing. Academic discussion of theoretical questions is not opportune (it hardly ever is at our meetings), nor discussion of after-war problems except in a general way and where they loom large.

Serious criticism has developed of many lines of engineering and production activities. On the whole vast accomplishment has been shown. It is well, even under the heaviest pressure, to stop occasionally and consider what has been accomplished as indicating what remains to be done. A meeting in this vein will be decidedly worth while. The views of those who have been engaged actively in France with our army or in the work of the Allies with whom we are associated will be had so far as possible. Technical discussion of this kind the members will readily divine will be of obvious advantage.

President Kettering has said most emphatically again and again that the Society should be more active than ever before, because there has never been a time when there were so many important as well as interesting things going on in automotive engineering of fundamental value to the Nation and the Allied cause; when as much could be learned; or when such a great amount of information was available from men who would impart it, as today. In his words, "The engineer has been the fellow that the commercial department told what to make and held responsible for its successful operation. There is a chance to learn now, to acquire broader ideas, entirely new conceptions of engineering subjects. We ought to take advantage of these things as never before."

There are a number of scientific subjects that are related intimately to the automotive industries in general. Let us take up the fundamental subjects: fuel, the thermodynamics of the internal combustion engine—the most important factor we have before us to-day. There is a wonderful opportunity this year of really learning more about the fundamentals of our industry than we have known before. Time is the function that marks engineering changes. Prewar models will have to be scanned closely when viewed for continuation after the war, whenever that may be.

Carburetion, including the use of heavy fuel and apparatus designed to compensate for variations in atmospheric density, will have to be studied. Fuel

distillation apparatus will have to be discussed and standardized. High-speed engine indicators are essential in fuel research.

"Super-charging" of aeronautic engines is a matter that will have to be threshed out. Air-flow through poppet valves must be reported on further.

Production and Inspection of Military Trucks; Base Repair Shop Organization and Operation of Trucks; and Motor Transport Service, are large special subjects.

Tanks; types of passenger cars after the war; radial-type aeronautic engines; relation in plane design of performance to size, weight, power and location of engine; tractors; type, design, production and inspection of gages, are subjects uppermost or not far distant in our minds.

Only in proportion as we abandon our prejudices, our empirical views, do we in many cases advance and learn as we should. The law of thought is the pursuit of logical unity. The aim of action is efficiency. The end of thought is truth. The aim of action is success.

The meetings of the Society have had much value. It is more important than ever that the members should meet together this winter, and this will prove to be the case.

THE WASHINGTON OFFICE SERVICE

It has always been one aim of the Society to render personal service to its members. One reason for maintaining the Washington office of the Society has been to assist members who desire to enter the Government service, either in enlisted, commissioned or civilian capacity, to secure information concerning the need for men of engineering and allied experience in the various branches of the Government. While several hundred members have availed themselves of this service during the past year, many others might well do so and thereby not only secure assistance themselves, but assist the Government by making it possible to more readily secure men much needed for engineering work.

Notices have been published from time to time in the "Men and Positions Available" columns in the advertising section of THE JOURNAL of the Government's need for certain men of experience in particular lines of engineering work. It is not, however, always permissible or desirable to publish particulars concerning all openings. On the other hand, the Washington office is always glad to give information concerning openings about which particulars are on file, provided a member requesting such information will furnish the necessary particulars concerning his training and experience, thus permitting an intelligent reply to his inquiry without useless reference to openings for which he is evidently unfitted.

The Government's need for men is continually fluctuating as demands are filled or new problems or conditions arise, making it at times imperative that additional qualified men be secured. Generally speaking, there are always openings for men of broad engineering experience, as well as for certain other classes of men, such, for example, as draftsmen.

A census of the membership, started in the spring of 1917, is used continually for reference, and a special file of correspondence with men who have expressed a particular desire to enter the Government service has been prepared and is proving most useful when requests for men needed immediately are received. Any member who writes to the Washington office concerning his desire to enter the service is listed as being available, and a summary of his experience is prepared for the convenience of both the office and the personnel officers who are frequently given access to the file.

Motor Transport Corps in Need of Men

At the present time the Motor Transport Corps can use the services of several versatile designers, especially those familiar with motor-truck work; several executives with factory and engineering experience; and a few engineers with experience in following up and reporting upon the performance of trucks in service, with a view to advising the engineering department concerning necessary changes or refinement. Men who deem themselves qualified for these particular openings may either address the Washington office of the Society or write direct to Captain A. L. Watts, Motor Transport Corps, Engineering Office, 358 Union Station, Washington, D. C. In so doing they should mention their connection with the Society, and give full particulars concerning training and experience, age, status in the draft, salary received in various positions, etc. Copy of such letter should be forwarded to the Washington office of the Society, 337 Munsey Building, and the writer will be referred to other openings if he desires, or is not found available for the positions above mentioned.

At the present time, men within the draft age are not being commissioned from civilian life unless they have deferred classification on other than occupational grounds. In some cases men otherwise qualified, but not in deferred classification for other than occupational reasons, may be commissioned after induction into the service as privates.

A new census blank will be sent to the members soon in order to supplement and bring up-to-date the somewhat incomplete information furnished by some members on blanks issued by the S. A. E. Committee on Preparedness before the United States entered the war.

The Diesel Engine*

By Herbert Haas (*Non-Member*)

THE DIESEL engine, a comparatively new type of internal combustion engine, is an important device for insuring more efficient utilization of petroleum and coal-tar products, for it consumes heavy liquid fuels such as cannot be utilized in other types. Like the gas or the gasoline engine, it is revolutionary within its province. For some uses this engine is replacing gas and gasoline engines, but its most important duty will be to replace the wasteful consumption of fuel oil in steam engines. Not only will a wider use of the Diesel engine relieve the demand, but it will result in more power being obtained from the same consumption of fuel oils. In spite of these advantages, comparatively few Diesel engines are in use in the United States.

The term "oil engine," as generally used at the present time, is applied to internal combustion engines that burn directly in the cylinder heavy liquid fuels of high boiling points, the fuel being injected into the compressed air shortly before or at the completion of the compression stroke. The heat of compression is used to ignite the fuel.

In the heavy-oil engine the vaporizing of the fuel takes place inside of the engine. As a fuel with a high boiling point cannot be evaporated at moderate temperatures, thorough mechanical division preceding ignition and combustion is necessary.

Three General Types of Liquid-Fuel Engines

According to the means used for atomizing the liquid fuels and igniting them, there are two mechanically and thermodynamically distinct types of engines. In one type the entire fuel charge is sprayed against a highly heated surface in a chamber connected with the working cylinder. Contact with this highly heated surface gasifies the fuel, which is ignited and burns with explosion-like rapidity. Engines of this type are properly termed "explosion oil engines," or engines in which the fuel is burned at constant volume.

In engines of the other type the fuel to be converted is finely subdivided by air, and in this act of atomization is injected directly into the engine cylinder, where it is ignited automatically by the highly heated air in the cylinder. The combustion is not explosion-like, but is prolonged at constant pressure for the entire period during which the fuel is injected into the cylinder. This type of engine is universally known as the Diesel engine, being named after the late Rudolph Diesel of Munich, Germany, its inventor. It is also termed a "constant-pressure oil engine."

There is a third general type of engine, combining features of the two types mentioned, in which the fuel is burned at both constant volume and constant pressure. Engines of this type are known as Sabathé engines.

In explosion oil engines, the air is compressed in the cylinder to a pressure of 145 to 220 lb. per sq. in. and in the crankcase (two-stroke cycle engine) to a pressure of 1 to 7 lb. per sq. in. The explosion pressure varies from 270 to 470 lb. per sq. in.

Diesel Engines

FOUR-STROKE CYCLE

Fig. 1 shows the elements of a Diesel engine having a four-stroke cycle. Important adjuncts of the engine comprise a two-stage air compressor *a*, air-injection bottle *b*, compressed-air container *c*, and fuel-oil tank *d*.

The engine piston has started on its downward travel. The air-admission valve *e* is open to the atmosphere and lets air into the engine cylinder. On its return stroke the valve *e* and all other valves are closed, so that the piston compresses the air in the cylinder to a pressure of 450 to 500 lb. per sq. in. As a result the air becomes highly heated, its temperature rising to about 1000 deg. Fahr. when the highest pressure is reached. When the piston is at its upper dead center, the fuel-injection valve *f* is opened and liquid fuel in a volume proportionated to the load of the engine is forced into the cylinder, where, meeting the highly heated air, it automatically ignites and burns. When an automatically regulated supply of fuel has been delivered, valve *f* closes.

Pump *h* is under the influence of the engine governor, by which the volume of fuel delivered is proportioned to the load of the engine. The fuel oil stored in tank *d* flows by gravity to the pump, which delivers a measured quantity of oil to the fuel injector *f* during the suction stroke of the engine piston, while the needle-valve of the injector is closed. The fuel injector is connected with the small air receiver *b*, in which air under a pressure of 700 to 900 lb. per sq. in. is stored, and air at this pressure always fills the valve chamber around the valve stem of the fuel injector.

Pump *h* in delivering its measured quantity of oil fuel to the injector must overcome the air pressure within the valve chamber. The pump is, therefore, designed to deliver the oil at a pressure of 100 to 200 lb. per sq. in. higher than the pressure of the air from the tank *b*, or at a pressure of 800 to 1100 lb. per sq. in. The fuel oil is delivered near the bottom of the fuel injector, immediately above the needle-valve. When this needle-valve is opened the injection air, which is at a pressure nearly double that of the compressed air in the engine cylinder at the completion of the compression stroke, atomizes the fuel oil and carries it into the engine cylinder. The injection air thus serves two important functions, namely, to inject the fuel into the cylinder and to subdivide it finely. The latter function is by far the more important, as on its efficiency greatly depends the success with which the heavy liquid fuels are burned. The fuel could be injected by direct pump pressure, but unless thoroughly atomized by highly compressed air it would burn only partly and after-ignition would result.

The two-stage air compressor *a* furnishes the injection air; *i* is an intercooler to cool the air from the low-pressure cylinder *j* to atmospheric temperature before delivering it to the high-pressure cylinder *k*; *l* is an aftercooler to deliver cold air to tanks *b* and *c*. As previously mentioned, in the compressor the atmospheric air is brought to a pressure of 700 to 1000 lb. per sq. in. The air receiver *b* provides reserve air storage. Air

*U. S. Bureau of Mines Bulletin 156 (condensed)

is drawn from it whenever the engine is started and is delivered through the starting valve *m*, when the piston is at the upper dead center, in position to receive a power impulse. After the engine has been started, tank *c* is recharged from tank *b*, by working the air compressor at its full capacity for 15 to 20 minutes. When the desired air pressure has been restored in tank *c*, all valves leading to and from the tank are closed. The air-inlet pipe is shown at *n* and the exhaust pipe at *o*.

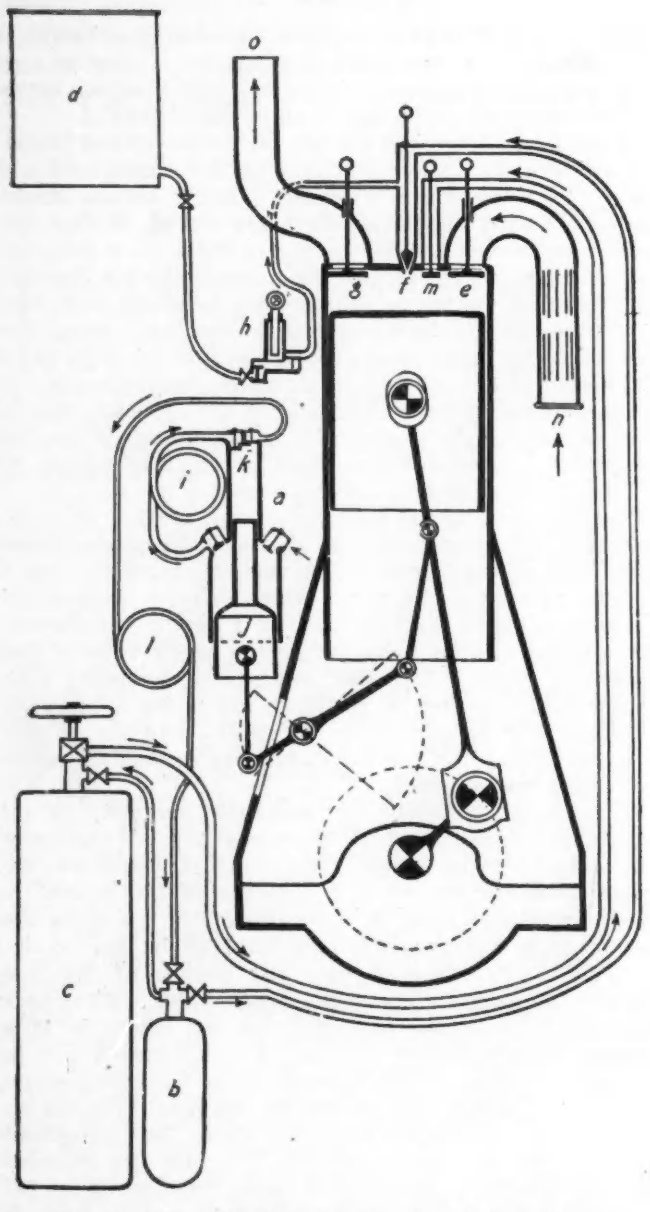


FIG. 1—DIESEL ENGINE HAVING A FOUR-STROKE CYCLE

a, air compressor; *b*, injection air bottle; *c*, reserve air receiver; *d*, fuel tank; *e*, air (intake) valve; *f*, fuel-injection valve; *g*, exhaust valve; *h*, fuel pump; *i*, intercooler; *j*, low-pressure cylinder; *k*, high-pressure cylinder; *l*, aftercooler; *m*, starting valve; *n*, air intake; *o*, exhaust

Starting a Diesel engine from no load to full load requires one to three minutes, depending on the size and the construction of the engine.

Two-Stroke Cycle

Fig. 2 shows the elements of a Diesel engine with a two-stroke cycle. It differs from the engine just described in that it has a scavenging air pump *a* and exhaust ports *b*, arranged around the cylinder walls, covered and uncovered by the piston in its upward and downward travel, and two or more air-admission valves in the cylinder head.

The scavenging air pump *a* is double-acting and its air delivery is controlled mechanically by a piston valve. The air admission to the engine cylinder is mechanically controlled by two or more air valves *c* in the cylinder head. The scavenging air is compressed to a pressure of 3 to 7 lb. per sq. in.

The air is admitted into the working cylinder as soon as the exhaust ports have been uncovered by the piston; the cylinder, full of the gaseous products of combustion, is cleared by the scavenging air, which sweeps out through the exhaust ports *b*. As the piston on its return stroke closes all cylinder valves and exhaust ports, the air is compressed in the same manner as in the engine having a four-stroke cycle, and the fuel charge is injected on the completion of the compression stroke.

In Fig. 2 the air-admission valves are shown in the cylinder head of the engine. In some later engines these scavenging air valves have been placed in the cylinder wall, opposite the exhaust ports. The piston is shaped so as to direct the travel of the scavenging air in the cylinder and to arrange it in currents that sweep the cylinder clean of the products of combustion. Thus the cylinder head is relieved of numerous air valves, which, by reason of space limitations imposed by the cylinder head, have to be of restricted area, necessitating greatly increased air velocities to effect the desired scavenging. The placing of these valves in the cylinder head also results in a complicated head casting, the water spaces of which are narrow and restricted, so that effective cooling is made more difficult. By the modified construction above mentioned, the cylinder head has only starting and fuel injection valves. The placing of the air valves in the cylinder head has the advantage of insuring a more thorough scavenging, as the air, entering at the top of the cylinder, will more effectively sweep before it the burned gases.

SABATHÉ ENGINES

Sabathé engines differ from the Diesel engines described only in the method of admitting fuel and that of timing ignition, these being accomplished by a fuel-injection valve and a governor of a construction peculiar to these engines. A part of the fuel is admitted before the upper dead center of the piston is reached, and burns with constant volume. The remainder is admitted at the completion and return of the stroke, and burns at constant pressure. If the engine load diminishes, the fuel admitted during the second, or constant-pressure, period is diminished, stopping entirely during low load when the only fuel admitted is burned at constant volume.

The peculiarity of the working cycle of these engines is well illustrated in the pressure-volume diagram shown in Fig. 3. The burning of the fuel is accomplished at constant volume as represented by the line *bc*, and at constant pressure as represented by the line *cc'*. The fuel, of course, is not introduced intermittently at *b* and *c*, but is admitted continuously, the burning at constant volume and pressure being controlled by the action and timing of the needle-valve, under the influence of the governor, at predetermined positions of the piston. Line *cc'* varies in magnitude with the load. At low load, line *cc'* disappears entirely; then the diagram becomes similar to that of an ordinary explosion oil engine.

Actual diagrams differ from the theoretical one shown in Fig. 3. In reality it is not possible to burn the fuel so quickly that it burns at constant volume. Line *bc* therefore inclines slightly toward the expansion line. The properties of the fuel, whether it burns readily or slowly, the temperature in the cylinder, and the means used for its ignition all influence the burning process. A part of the fuel usually does not burn until expansion has begun.

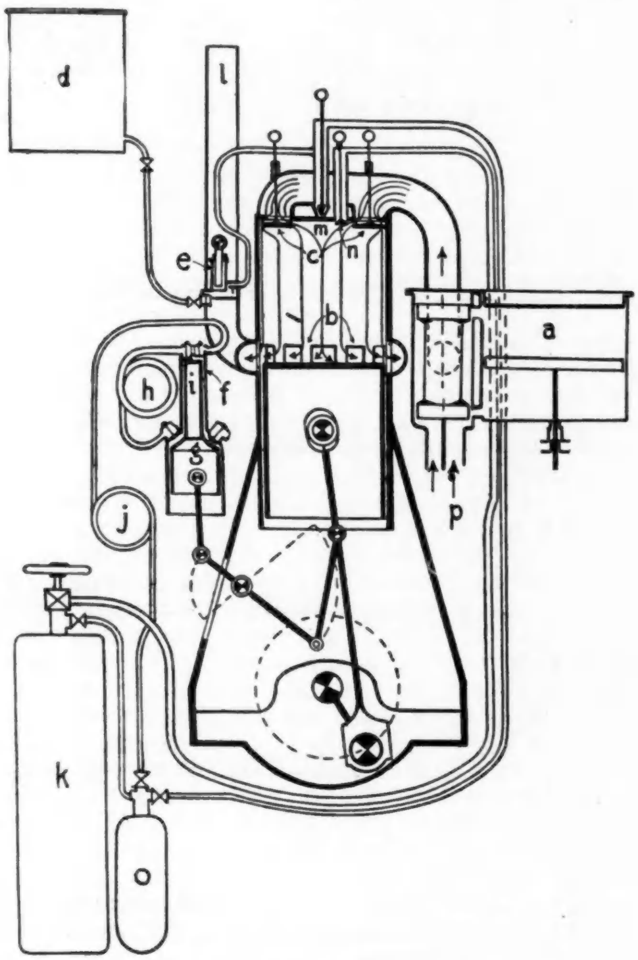


FIG. 2—DIESEL ENGINE HAVING A TWO-STROKE CYCLE

a, pump for air scavenging; *b*, exhaust ports; *c*, air valves; *d*, fuel tank; *e*, fuel pump; *f*, air compressor; *g*, low-pressure cylinder; *h*, intercooler; *i*, high-pressure cylinder; *j*, aftercooler; *k*, air receiver; *l*, exhaust pipe; *m*, fuel injection valve; *n*, starting air valve; *o*, injection air bottle; *p*, air inlet pipe

Likewise, in Diesel engine diagrams, there is no perfect constant-pressure line. With the admission of the fuel, there is a slight increase in pressure; there is also an after-burning of incompletely burned fuel when expansion has started, so that the initial and the terminal parts of the constant-pressure line are slightly curved.

In explosion oil engines the constant-volume line *bc* of Fig. 3 is shortened, and the diagram area is decreased, with a decrease in the fuel supply during fractional loading of the engine.

In the Diesel engine the constant-pressure line is shortened, and the diagram area decreased, with partial loads. In some two-stroke engines that increase the specific duty by increasing the scavenging air pressure, that is, by pumping a greater weight of air into the working cylinder, the compression pressure is variable, and decreases with a decrease in load to the minimum required for satisfactory burning of the fuel. Fig. 4 shows actual indicator diagrams for different loads of a Diesel engine having a four-stroke cycle.

Comparative Advantages of the Cycles

As regards the relative theoretical advantages of the four-stroke and the two-stroke engines, the two-stroke engine appears to be superior. For a given cylinder size and speed, the specific duty of an engine having a two-stroke cycle is double that of an engine having a four-stroke cycle, for it receives a power impulse for every revolution as against one for every two revolutions of the engine having a four-stroke cycle. Its mechanical efficiency also would appear to be greater, as the engine with a four-stroke cycle has to make two strokes for expelling the products of combustion and for filling the cylinder with a fresh supply of air for burning the next fuel charge. The power for this work has to be drawn from the flyweel, in which it has to be stored again during the power stroke. As in addition the cyclic regularity of an engine with a four-stroke cycle but having the same power and speed is greatly less, a much heavier flywheel is required. The four-stroke engine is also much heavier per horsepower than the two-stroke engine.

In practice, however, these advantages are not so apparent. Engines having a two-stroke cycle require an auxiliary air pump for performing the work of scavenging and of refilling the working cylinder with fresh air, work that in the engine having a four-stroke cycle is performed by the engine directly in the working cylinder. The air pump, proportioned to the engine it has to supply, is a large and heavy piece of machinery, requiring considerable power for its operation. To insure thorough scavenging of the working cylinder, a volume of fresh air greater than the volume of the cylinder must be supplied by the air pump. The pump is usually proportioned to supply one and three-tenths times the working cylinder volume of air. Even then sweeping of the working cylinder clean of the remnants of the products of combustion is difficult, and any gases remaining in the cylinder displace a proportionate amount of oxygen needed to maintain combustion, thus lowering the possible power output of the engine.

The heat exchange in an engine having a two-stroke cycle being more rapid than in one having a four-stroke cycle, the material of the former is more severely taxed,

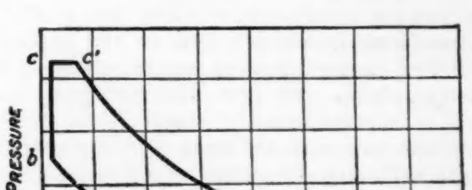


FIG. 3—PRESSURE-VOLUME DIAGRAM, SABATHÉ FOUR-STROKE CYCLE ENGINE

and it is not advisable to use as high mean effective pressures or piston speeds as in engines having a four-stroke cycle. High mean effective pressure results in high terminal pressure at the time of exhausting, with a consequent loss in power. As the exhaust ports of two-

stroke engines are uncovered by the piston, and as exhausting of the gases must be rapid, the piston has to uncover these ports several degrees before it reaches its lower dead center. High mean effective pressure will therefore cause proportionately greater losses in an engine having a two-stroke cycle than in one having a four-stroke cycle. These features combine to diminish the theoretical advantages that engines having a two-stroke cycle appear to possess over engines with the simpler four-stroke cycle.

To avoid any misconception it is well to emphasize that the difficulties and the considerable fuel losses during exhausting experienced with the usual two-stroke gas engine, chiefly on account of the successive scavenging and loading of the engine cylinder, are absent in the two-stroke Diesel engine. In this engine the same air pump does the scavenging and the charging, whereas in the two-stroke gas engine separate pumps are used for scavenging and for charging the cylinder with the gas-and-air mixture. These pumps consume considerable power, and it is difficult to prevent a part of the fresh gas-air charge from being expelled with the products of combustion during exhausting. Having to deal with inert air (air not mixed with any combustible gas) and a liquid fuel, the working process of the two-stroke cycle Diesel engine is much simpler than that of the gas engine having a two-stroke cycle.

Engines with a four-stroke cycle, in sizes from 50 to 800 horsepower,* have been developed to a high degree of perfection, and are so simple in operation that little justification for the adoption of two-stroke engines in these sizes exists at present. The field of two-stroke type lies chiefly in engines of very small and very large powers, the latter from 1000 horsepower upward.

Engines of Small Power

Diesel engines, to insure high fuel economy, demand mechanically operated valves, and a high-pressure air compressor, which, together with the high-compression and resulting high temperatures used, demand the highest grade materials and workmanship, involving a high cost per horsepower.

Although in European countries Diesel engines are manufactured in sizes as small as 15 horsepower there is little demand for this size in America, where fuel prices generally range lower, and where Diesel engines of 75 horsepower indicate the probable commercial limit in size. For large powers, from 1000 horsepower upward, engines having a two-stroke cycle are preferred, as in these sizes limitations are put on the size of cylinder practical for engines having a four-stroke cycle by the high temperatures and pressures produced in such engines. An increased use of material to withstand the greater total pressure in large cylinders merely accentuates the difficulty of cooling the cylinder, the cylinder head, and the piston, and of carrying off the heat fast enough through thick cylinder and cylinder-head walls. Stresses due to unequal expansion and contraction may easily lead to ruptures of vital engine parts, such as cylinder heads, pistons and cylinders. Successful building of large Diesel engines must therefore be fortified by a great amount of practical experience, particularly in the rational design and selection of casting mixtures with correct chemical and physical properties.

Twenty-four inches in cylinder diameter represents the probable upper limit with air-cooled pistons, and 30 inches with water-cooled pistons, for Diesel engines having a four-stroke cycle.

*The British horsepower is used throughout this publication. The British horsepower is 1.0139 metric horsepower, or 76.041 m. kg., whereas the metric is 75 m. kg. per second

Economies of Diesel and of Explosion Oil Engines

The use of explosion oil engines should be dictated entirely by their over-all economy. Although they are materially cheaper in first cost, they consume considerably more fuel and lubricating oil than Diesel engines, and their fuel consumption at fractional loads increases at a greater rate than does that of Diesel engines.

The difference in economy between explosion oil engines and Diesel engines is due not so much to a difference in thermodynamic cycles as in constructional differences, which decidedly favor the Diesel engines.

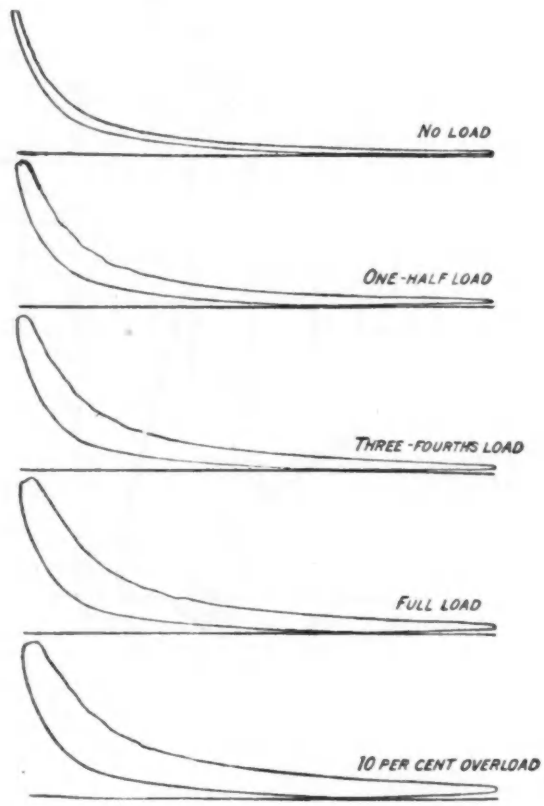


Fig. 4—Indicator Diagrams of a Diesel Engine Having a Four-Stroke Cycle

If the compression were carried as high in the explosion engine as in the Diesel, the explosion oil engine would show theoretically a slightly higher thermodynamic efficiency than the Diesel engine. The final pressure, when the fuel is burned at constant volume, would, however, be greatly increased above the compression pressure, or to about 60 atmospheres, with an accompanying rise in temperature far beyond that practicable with the materials of construction available. These limitations impose a lower compression pressure on explosion oil engines than on Diesel engines, so as to keep the maximum pressure and temperature within safe limits of permissible engine construction.

Thus with a compression pressure of 150 to 250 lb. per sq. in. the explosion pressure becomes 270 to 500 lb. per sq. in.; and with the instant ignition and burning of the previously vaporized oil common to explosion oil engines, a temperature of 2300 deg to 3150 deg. Fahr. is reached.

The Diesel engine has a higher but more gradually

increasing compression pressure (450 to 500 lb. per sq. in.) which does not subject the engine to sudden shocks, with a resulting increase in temperature from atmospheric to about 1000 deg. Fahr. The fuel is gradually injected as the piston moves from its top center (inner dead center) downward, the pressure remaining practically constant during the time of fuel admission. With a decrease in load, the time of fuel admission is also shortened, that is, the fuel supply is shut off sooner. Therefore, the increase in temperature due to the burning of the fuel at constant pressure does not exceed that reached in an explosion engine, notwithstanding the higher compression pressure used in the Diesel engine, and the higher initial temperature caused by this compression. Thus, the temperature in a Diesel engine seldom exceeds 2600 deg. Fahr., and reaches 3000 deg. Fahr. only when the engine is overloaded.

If, then, the working cycles of the two types of engines are compared on the basis of compression pressures used, the Diesel engine is found to have a greater thermal efficiency, because it can work successfully with the higher compression pressure. This superiority is confirmed by comparative entropy diagrams.

Whereas in explosion oil engines the efficiency is influenced by the compression ratio alone, in the Diesel engine the efficiency is influenced by the compression and the cut-off ratios, the efficiency increasing with a decrease in the length of the cut-off or constant-pressure line. Thus, at fractional loads, the indicated thermal efficiency of Diesel engines increases, which partly offsets the loss in mechanical efficiency, that is, the increased fuel consumption for performing the internal work of the engine. This accounts for the very "flat" fuel-consumption curve of Diesel engines, which maintain an almost constant fuel economy over a fairly wide range in load. Thus at three-fourths load the increase in fuel consumption per brake horsepower-hour is only 2 to 5 per cent, and at one-half load 10 to 15 per cent greater than at full load in high-grade engines, which is in marked contrast with fuel increases in other prime movers. The ability to create higher initial temperatures, aside from increased thermal efficiency, enables the Diesel engine to burn a greater variety of fuels. In addition to the fuel being thoroughly atomized by highly compressed air, the heated oxygen has an augmented power of combining with the carbon and hydrogen in the fuel, so that the velocity of the chemical reaction at the high temperature in a Diesel engine is greatly increased. As a result the range of fuels suitable for the Diesel engine comprises such heavy liquid fuels as petroleum residues, coal-tar oils, and coal tars.

A serious fuel loss in explosion engines is frequently caused by the decomposition of the fuel oil sprayed into the hot ball. Various hydrocarbons are formed with a separation of carbon and oil soot; part of this coats the hot ball and the cylinder, and a larger part is expelled with the gaseous products of combustion. From time to time accumulated soot in the exhaust piping catches fire and burns, necessitating precautions against fire from this source.

In the first Diesel engine planned, coal dust was to be the fuel. The adiabatic terminal pressure was to reach 250 atmospheres, and was to drop to 90 atmospheres with the termination of the isothermal combustion of the fuel. The cylinder was not to be water-cooled, but to be insulated against all radiation of heat. The thermal efficiency was to be 73 per cent. On account of the high pressure and temperatures involved and the small amount of useful work obtained, the original cycle was changed to that which has been in use for the past 20 years. It still remains the nearest approach to the Carnot cycle. The Diesel engine with its 45 per cent indicated thermal efficiency is the most efficient heat engine of to-day. The efficiency of the Diesel cycle is about 60 per cent, of which 75 per cent is realized in indicated work (45 per cent net indicated thermal efficiency) and 60 per cent in effective mechanical work (36 per cent net effective thermal efficiency) in high-grade, four-stroke engines at full load. Two-stroke engines have a slightly lower efficiency.

Vertical Diesel Engines

Inasmuch as most engines are used for the generation of electric current with direct-connected generators, four-cylinder units are necessary to obtain the desired cyclic regularity for satisfactory generator performance in engines having a four-stroke cycle, especially when two or more units are to operate in parallel. Multicylinder units also permit a higher number of revolutions, by shortening the stroke without necessarily increasing the piston speed of these units. Such features combine to produce a compact, relatively light engine. The closed crankcase is the construction favored for medium and high-speed engines, with which forced-feed lubrication is used. There is no spilling and spattering of lubricating oil, and the engine and engine-room floor are easily kept clean. The forced-feed lubricating system, at first used only on high-speed units, has proved so satisfactory and so economical in the use of lubricants that it is used increasingly on medium and low-speed engines. In Europe manufacturers have adopted this closed crankcase construction for units up to 1000 horsepower.

In larger engines, which require the use of A frames, the panels are connected with steel sheets provided with large doors between the individual frames, so as to obtain the advantages of a closed crankcase and of forced-feed lubrication.

On the bedplate is also mounted the multistage air compressor, usually in a vertical position to preserve the symmetry of the engine.

Construction of Cylinders and Cylinder Frames

The cylinder frame receives the cylinder liner which has at the head end a heavy flange fitted to the cylinder frame. A registered joint is either placed wholly in the top of the flange of the cylinder liner or is divided over the top of the cylinder frame and the liner. Some constructors prefer the latter method, to insure a water-tight and a gas-tight joint. The cylinder head is provided with a corresponding ring that fits into the registered joint, soft-copper packing rings being inserted between the surfaces.

The top end of the cylinder frame must be so designed as to provide ample metal, as in it are secured the stud bolts that hold the cylinder head and are subject to heavy stress.

The cylinder liner is provided in the middle with a machined rib or ring to center the liner and also to give it lateral support against a similar ring cast integral with the cylinder frame. The bottom part of the liner has another ring provided either with a gland ring or a groove into which fits a circular rubber packing ring. Both methods are used to insure a water-tight joint between mantle and liner. The cylinder liner is fixed only at the head end, and is therefore free to expand in the other direction.

The use of separate castings for the mantle and for

the cylinder liner is important, as the cylinder liner becomes much hotter than the mantle, so that the unequal stresses produced in the two are likely to fracture a cylinder if cast integral with the mantel. Separate liners can be designed and made of the most suitable material; in case of excessive wear or fracture, they can be cheaply and easily replaced. On account of the rapid alternations of exceedingly high and low temperatures, cylinder liners are preferably made of a special close-grained cast iron of high tensile strength—capable of withstanding a load of 40,000 lb. per sq. in.—and able to withstand severe shock tests.

For cylinder lubrication the cylinder frame and the liner are perforated in four places, and oil passages consisting of small copper pipes are inserted between the mantle and the liner, and bridge the water space. These oil passages are in the same plane in the middle part of the cylinder, being spaced 90 deg. apart, and 45 deg. removed from the axis of the main shaft. As the front and the back cylinder walls receive the principal pressure, the oil feeds in these cylinders are sometimes set closer together, so as to feed the oil more freely to the surfaces most taxed.

Construction of Crankshaft

The high pressures common to Diesel engines demand proportionately heavy crankshafts. These are forged from the solid, a ductile low-carbon steel being used. Some manufacturers use nickel-steel shafts. For large engines, or for an engine made of two half units, the shaft is composed of more than one piece, although the common practice for stationary engines is to use one-piece shafts, even if four cranks are used.

Methods of Lubrication

When the shaft and the connecting-rods are not drilled for forced-feed lubrication, it is usual to provide each crank with a centrifugal oiling ring to deliver the oil to the crank-pins. For this purpose the crank-pins are drilled, the drilled passages receiving the oil from the rings and delivering it to the pin brasses. Oil-drip rings turned out of the solid material of the shaft confine the oil to the main bearings and lead it to the oil reservoirs in the crank-pit. On the shaft is mounted the helical gear for engaging a like gear on the governor shaft and driving it, the gears dipping into the oil. A crank-pin for driving the air compressor is part of the main shaft and is lubricated in the same manner as the other pins. The flywheel and the driving pulley are usually mounted on an enlarged part of the shaft, the extension of which is carried in an outboard bearing.

The main bearings for this type of shaft are either provided with an oiling ring or are constantly flooded with oil under pressure issuing from a piping in the cover of each bearing. The surplus oil is collected in the crank-pit and is filtered and cooled, and is returned to the bearing by a pressure oil pump. A circulating system of this kind insures positive lubrication of the main bearings, whereas oiling rings may possibly stick.

Another system of lubrication, essential to high-speed and even medium-speed engines, and, on account of its satisfactory operation and sparing use of lubricants, favored increasingly for high-grade low-speed engines, is illustrated in Fig. 5. Drilled passages run from the middle of the main bearings diagonally through the middle of a journal and the webs of the cranks and issue in the middle of the crank-pins. The connecting-rod is hollow. Whenever these passages register, a part of the oil, aside from lubricating the main and the crank-pin bearings, is forced through the hollow connecting-rod and lubricates the piston-pin bearing. The oil is initially forced under pressure through the covers of the main bearings. In other engines the oil is supplied through the bottom of each main bearing, permitting a simple arrangement of the oil piping and obviating the necessity of breaking pipe connections when the bearing covers are removed. The surplus oil is collected in the crank-pit, flows to a filter through a cooler, and is returned to the bearings by a positive-pressure pump, driven direct from the main engine by either gearing or side cranks.

The lubricating system last described effectively lubricates the piston-pin bearing, which is of particular importance, as its position inside the trunk piston and in close proximity to the piston head subjects it to heat by absorption and conduction, in addition to the severe duty it has to perform regularly in transmitting the high piston pressures. Engines using centrifugal oiling rings have a separate oil supply for the piston pin.

In vertical engines one of the plungers of a forced-feed oil pump used for cylinder lubrication delivers oil through a feed in the cylinder frame and the liner to a vertical groove in the piston. This groove is above the piston pin and is connected with drilled passages in the piston and the piston pin, and through these passages the oil is fed to the pin bearings.

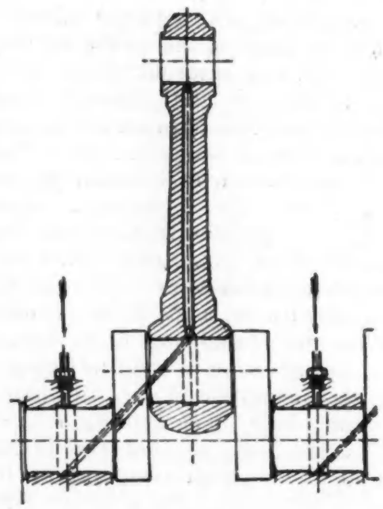


FIG. 5—SYSTEM OF LUBRICATION ESPECIALLY ADAPTED TO HIGH-SPEED ENGINES

In horizontal engines with trunk pistons the feeding of the piston-pin bearing is simple. An inclined oil-feed pipe provided externally with a wiper is fastened to the inner wall of the trunk piston. With every stroke of the piston a measured supply of oil furnished by a separate plump plunger is carried to the piston-pin bearing.

Main Bearings

The main bearings are usually semicylindrical, babbitted, cast-steel shells, carried by carefully machined seats cast integral with the bedplate, the shells being held down by their covers. They have no wedge adjustment, but rest rigidly in their seats. In practice it has been found difficult to keep numerous adjustable bearings in perfect alignment, and inequalities in adjustment of the different bearings have frequently led to broken shafts.

With the bearings once carefully machined and aligned in the shop the wear over all bearings is uniform and light in high-grade engines, in which the bearings are flooded with oil from a forced-feed system, uniform bearing pressure being insured through an equally proportioned supply of fuel oil furnished to each cylinder. By raising the shaft slightly the shells can be rolled out for rebabbitting.

Connecting-Rod

The connecting-rod is forged of soft, low-carbon steel and has a hollow center in engines using forced-feed lubrication. Hollow rods are often used, especially in small engines, to decrease weight. The crank-pin end is usually provided with a marine head, the boxes of which are either lined with babbitt or bronze, the head proper being of cast steel. The piston-pin end of the rod is usually slotted out of the solid to receive an adjustable box made of cast steel or cast iron lined with babbitt and bronze. Adjustment is made either by shims held by adjusting screws or by wedges. The positive rigidity obtained with square shims and adjusting screws is usually given preference over the wedge adjustment. For large engines a marine head for the piston end is sometimes preferred as offering greater ease of adjustment; however, it offers no advantages over the closed head when it has to be removed. The piston and rod of either type are pulled through the top of the cylinder and the rod is removed by knocking out the piston-pin. In horizontal engines the pistons are pulled out of the open bottom of the cylinder, so that the heads do not have to be removed, an advantageous arrangement. Some types of vertical engines are so built as to permit pulling the piston from the bottom of the cylinder.

Pistons

On account of the relatively short connecting-rod and the high pressure common to Diesel engines, the resultant side pressure on the cylinder wall is high. Therefore, the trunk pistons must be correspondingly long to keep the unit pressure within safe limits and to reduce excessive cylinder and piston wear. For this reason crossheads and guides were used during the earlier development of Diesel engines in Europe. On account of its many advantages the trunk piston has been adopted and is used in engines, even of 250 horsepower per cylinder and in units of 1000 horsepower. The trunk piston is more easily provided with a greater bearing surface than a crosshead, thus insuring less wear; the lubrication under pressure of a cylindrical guiding surface is more effective than with open guides. The piston moves over perfectly cooled walls, whereas the crosshead tends to heat more readily and when once hot is not easily cooled; moreover, water-cooled crossheads complicate construction. The use of crossheads and guides greatly augments the height or the length of the engine, increasing its cost. For large engines this construction is used, as it affords greater accessibility and ease of adjustment, the crosshead guide in such engines being water-cooled.

To confine the wear to an easily and cheaply replaceable part of the piston, in some constructions the piston on the side subjected to the reaction pressure is provided with soft, cast-iron wearing shoes, which can be raised slightly by the interposition of thin sheet-metal shims, when shoes and cylinder are worn. However, this construction is not extensively used, as, with good design and workmanship and thorough lubrication, the wear is slight and is noticeable only after years of work. Cylinder wear is usually due to an excessive sand or ash content in the fuel oil used and not to piston side pressure.

The cylinder liner is cast sufficiently heavy to permit of reboring.

From five to seven snap rings are used to seal the cylinder. To hold the rings closed they are pinned together at the lap joints. They are pinned to the piston by a small dowel set in a hole in the groove. Such fastening is always necessary in two-cycle engines to prevent the ends of the snap rings from shifting around the piston and thus traveling across the exhaust ports and catching in them while they are being uncovered or covered by the piston.

At the bottom of the piston another ring is placed, serving as an oil-wiping ring and preventing the drawing of splashed oil from the crankcase and the reciprocating parts into the engine cylinder. This feature is of importance in a high-speed engine with a closed crankcase.

Pistons of small size are cast in one piece; those of larger engines are cast in two pieces. The limiting size for the one-piece and the two-piece construction differs widely with different builders. In the two-piece construction the piston top with the snap rings comprises about the upper one-third of the piston. In the lower piece is placed the piston-pin. That part of the piston subjected to intense heat and great wear by the impinging of the fuel and air jets can thus be cheaply replaced. The top of the piston is either a plane surface or has a concave depression. To reduce the clearance space to a minimum and to obtain the required compression, the piston is permitted to come close to the head when at its top center by cutting out recesses in the top of the piston for the air inlet and exhaust valves. To prevent excessive wear of the central top part of the piston, upon which the fuel and the injection air impinge, a nickel or steel plate is sometimes cast into that part. Other constructions provide a small cone to distribute the fuel radially over the entire combustion space and to improve the combustion of the fuel. The construction of the piston is largely a matter of practical experience. The interior of the trunk is provided with reinforcing ribs for strength as well as for radiating heat readily. On account of the repeated heat changes and high pressures, the piston is heavily taxed. Notwithstanding, all material must be used judiciously and in the right place, as any excess iron will serve only as a heat accumulator and subject the piston to severe internal stresses caused by differences in temperature in different parts of the piston. A light piston is also desirable to reduce the weight of the reciprocating masses.

Large pistons are jacketed and cooled by oil, water, or air and water. The oil or water is either circulated through the jacket space, or the water is sprayed with air against the inside surface of the piston top.

In some engines oil is used for piston cooling, to prevent contamination with water of the lubricating oil in the crankcase, should the moving pipe connections supplying the cooling medium spring a leak. However, the use of oil as a cooling medium is not general as its specific heat is only about half that of water. Water is also far superior for transmitting heat. As satisfactory mechanical constructions have been developed that insure a continuous supply of cooling water to the piston with small likelihood of leaks, the use of oil has been superseded by that of water even by builders who have long adhered to the former practice.

The water for piston cooling may be circulated through telescopic pipes, with the stuffing-box a moving part of

the piston, or the stuffing-box may be attached to the frame and the water be supplied to the piston through hollow walking arms through which the water flows to the pipes leading into the piston. A pump may be actuated from the crosshead and the water be carried to the piston through the hollow piston-rod. In another cooling system water is sprayed by air against the heated piston surface, not enough water being used to fill the water space of the piston. The excess water drains off through a pipe surrounding the spray pipe, no stuffing-box being used.

There is no uniform practice among manufacturers regarding the size of engine at which a change from air-cooled to water-cooled pistons is made. Some use water-cooled pistons when the cylinder reaches 125 horsepower. Others build air-cooled pistons for cylinders of 250 horsepower. In construction involving a closed crankcase, which gives little opportunity for air-cooling of the piston, the former practice is favored, whereas for horizontal engines in which the interior of the trunk and the part of the piston extending outside of the cylinder are exposed to the air the higher limit may be used.

Pistons of two-stroke cycle engines, in which the scavenging air is admitted through ports in the bottom of the cylinder, have special shaped tops to direct the flow of the scavening air.

In horizontal engines, the ratio between the length of connecting-rod and that of the stroke is generally greater than in vertical engines; a ratio of 3 is common, so that the reaction pressure against the side of the cylinder is usually less than in vertical engines, even allowing for the additional pressure due to the weight of the piston, which is always slight compared with the total side pressure on the cylinder.

The cylinders are lubricated by providing each cylinder with a force-feed pump operated by a reducing motion from the end of the piston, or with a multiple-plunger pump driven by an eccentric device or direct from the camshaft, one plunger being provided for each working cylinder and one for each air-compressor cylinder. In some engines two plungers per cylinder are provided, one for each pair of the four oil feeds grouped around the cylinder. Vertical two-stroke Diesel engines usually have a separate oil feed above and below the exhaust ports to prevent any excess of lubricating oil from being swept through the exhaust ports. Horizontal two-stroke engines usually have the exhaust ports in the sides of the cylinder, the parts of the cylinder serving as top and bottom guides being solid; the lubricating oil can then be so distributed over the bearing surfaces as to occasion little if any loss through the exhaust ports, and separate oil feeds are not needed.

Flywheel

Commercial as well as technical reasons impose limitations on the size of single-cylinder units. These seldom exceed 150 horsepower and then are usually confined to horizontal engines for industrial uses, allowing a liberal variation in speed. Two-cylinder units are built in sizes of 50 to 300 horsepower, and three and four-cylinder units in sizes from 100 horsepower up. The flywheel of a one-cylinder engine, if used on a four-cylinder engine with the same size of cylinder and four times larger power, will cause a cyclic regularity nearly 400 per cent better than that of the one-cylinder unit. Multicylinder units are considerably lighter; the smaller-sized cylinders allow shorter strokes and therefore higher rotative speeds, and these reduce the required flywheel weight.

The maximum variation from uniform speed differs widely for different classes of work required of the engine. The irregularity factor may vary as follows:

For driving pumps, punches, shears, and machines requiring a low degree of regularity, one-twentieth to one-thirtieth.

Machine tools, looms, and paper machinery, one-thirty-fifth to one-fortieth.

Spinning machinery, according to class of work, one-sixtieth to one one-hundreth.

Direct-current generators, one one-hundred-and-fiftieth.

Alternating-current generators, one two-hundred-and-fiftieth to one three-hundredth.

Making allowance for the different classes of power service that Diesel engines have to perform, manufacturers usually provide standard light, medium, and heavy flywheels for all engines, the medium and heavy flywheels of smaller engines being also available as light and medium flywheels for progressively larger machines. The set of flywheels used on one-cylinder engines is also used on multicylinder units with cylinders of same size.

One-cylinder units should not be used if the permissible variation has to be less than one-fiftieth; two-cylinder units may be used if the factor of irregularity does not have to be less than one one-hundredth; one two-hundredth is the limit for three-cylinder units, and one three-hundredth or less for four-cylinder units.

Limitations as to weight and dimensions of engine and flywheel, floor-space requirements, the more perfect balancing of the much-reduced reciprocating masses, and the great compactness will often decidedly favor the multicylinder unit, especially when the Diesel engine is to be directly connected to an alternating-current generator and two or more units are to operate in parallel.

Fuel Valves

Next to the fuel pump, the fuel-injection valve is the most important and characteristic part of a Diesel engine, and on its correct construction greatly depends the satisfactory operation of the engine. It performs two distinct functions. First, it has to admit the liquid fuel into the engine cylinder at the proper time, and must therefore be an accurately timed valve. Second, it has to introduce the liquid fuel into the cylinder in a completely atomized form, and must therefore be an efficient atomizer.

The first requirement is fulfilled by storing around the tip of the fuel needle a drop of oil, which is forced ahead of the injection air into the heated atmosphere of the engine cylinder at regularly recurring intervals, and thus initiates the ignition. The second requirement is accomplished by dividing the fuel supply into numerous small fuel particles in the fuel valve, preceding atomization and injection.

In the atomizing nozzle of the fuel valve a part of the pressure of the injected air is changed into velocity, which reaches its maximum at the orifice of the nozzle. Owing to the expansion of the air at the orifice there is a decided drop in temperature at this point, where the ignition of the fuel is to be initiated. This localized lowering of the temperature at the nozzle orifice is accentuated during periods of low load, when the fuel supply is diminished proportionately to the engine load, whereas the injection air supply remains constant, that is, the same as at full load, because the fuel-valve needle stays open during 10 to 15 per cent of the stroke of the engine, irrespective of the load. The relation of fuel supply to air supply is therefore changed with a change

in load. It is consequently more difficult to initiate the ignition at partial than at normal engine loads. A correctly designed fuel valve must be so constructed that unfailing fuel ignition at the proper instant will take place for every working impulse. Moreover, the atomization and injection of the fuel must be gradual during the entire period the needle valve is open.

Preheating of the injection air to counteract a cooling effect during fuel injection not only constitutes an element of danger owing to possible fuel ignition in the fuel valve, but results in an uneven, knocking operation of the engine as a result of explosion-like ignition of the fuel.

Starting Engine with Gas Oil

To permit the burning in Diesel engines of coal-tar oils (a by-product of coking and gas-works operations and a distillate of coal tar), two methods have been used. One is to start the engine with gas oil and after it has become hot change to tar oil. The governor and the fuel pump are so designed that with a lowering of the load the fuel is changed to gas oil and vice versa. This method has the disadvantage of causing an unnecessarily large quantity of gas oil to be consumed if the engine works a large part of the time at fractional loads.

In another system separate fuel pumps are used for the gas oil (also referred to as ignition oil, because it initiates the ignition) and the coal tar or tar oil. The two oils are stored separately in the fuel valve, the ignition oil being so placed around the edge of the end of the valve needle that it will always enter the combustion space first, and thus initiate the ignition. The fuel is injected with compressed air as in the other valves previously described. The proportion of gas oil to tar oil used varies with the load. At no load the gas oil amounts to as much as 20 per cent of the tar oil; at quarter load it drops to 15 per cent, at half load to less than 10 per cent, at three-quarters load to 4 per cent, and at full load and at overload to about 3 per cent. During average operating conditions the consumption of gas oil seldom exceeds 10 per cent, and is usually 7 per cent. The combined fuel consumption, on a basis of heating value, is nearly the same as if only gas oil were used. Both pumps are, of course, under the influence of the engine governor. The nicety and sensitiveness of this highly successful process may be realized from the fact that the volume of gas oil injected ahead of the tar oil is exceedingly small.

If the fuel oils, tar, or tar oils are highly viscous and do not flow readily to the fuel pump and to the fuel valve and resist atomization, gas oil is used to start the engine and run it until hot, and the hot discharge water from the engine jacket is used to heat the viscous oil to increase its fluidity. This system requires a separate small tank for the gas oil, in addition to the one used for the viscous fuel oil, and the pipe system must be so arranged that either fuel can be supplied to the fuel pump. When the engine is to be shut down, the gas oil should be switched on and the engine operated on gas oil until all of the viscous oil has been displaced. This arrangement works satisfactorily except when the operator forgets to change over to gas oil before stopping the engine or in the event of an unforeseen sudden shutdown owing to some engine trouble. These contingencies are so rare that separate fuel pumps and pipe systems for the two kinds of fuel are seldom provided.

The methods of using tar oils described are of no immediate importance in the United States, where an abundant supply of petroleum products (gas oils and residues) is cheaply obtainable, and coal tar commands relatively higher prices. In Europe, particularly Germany, petroleum residues and gas oils are expensive, and the abundant supply of tar oils from by-product coke ovens and coal-gas works justifies their use by the method outlined.

Methods of Actuating Valves

The usual method of actuating the valves of vertical engines is through a system of rocking levers and cams. The governor, usually of the through-shaft type, is mounted on the vertical shaft, as this has the higher speed. This arrangement permits the use of a smaller governor of the standard type. Governors for horizontal engines are driven from the lay-shaft, which also operates the valve gear. This shaft runs at half the speed of the engine shaft in engines having a four-stroke cycle. The governor is therefore speeded up through a set of spur gears, so that a smaller size can be used.

The engines are provided with a barring mechanism for turning the cranks into starting position. It is also necessary to pump by hand or by other means to force a small quantity of fuel oil into the pipes leading to the fuel valves, so that the engine will fire quickly.

When the air receivers are placed on the engine-room floor separate from the engine, the operator, if only one is present, will have to mount the engine platform for making the different valve shifts, as well as step down to open or close the valve of the air receiver.

To make possible the performance of this work from the engine-room floor, including the simultaneous engaging or disengaging of all of the starting valves or fuel valves, a system of auxiliary cams is used, controlled centrally from the engine-room floor. This system also permits holding the exhaust valves open during a part of the compression stroke to save compressed air in starting. By shifting the auxiliary cams out of action the regular cams come into play when the engine is running on fuel.

In one construction the air receivers for the air used in starting and injecting the fuel are attached to the front of the engine, being mounted sufficiently high so that the air-receiver valves can be operated and all other movements directed from the engine platform. With this arrangement the accessibility of some parts of the engine suffers somewhat.

In another construction mechanically operated starting valves are eliminated, independent air-operated piston valves being substituted. These receive the starting air through a rotary distributor operated by the camshaft. The rotary distributor can be connected or disconnected when the engine is running or is at rest. The fuel valves likewise are thrown in by a central control. This construction eliminates the cam and the fulcrumed lever for each starting valve used with the other types.

As a rule only one or two cylinders of a multicylinder engine are provided with starting valves, thus reducing the cost of the engine. In some engines automatic means are provided for keeping the exhaust valve open during starting, compression being avoided until the engine is well up to or past its normal speed to save compressed air in starting. Some horizontal engines have a blow-off cock in the end of the cylinder, which is kept open for a time in starting; this is also used to blow off accumulations of dirty and spent cylinder oil.

As the exhaust valves soon become fouled with carbon, they have to be ground often, and it is desirable that they be readily removable without disturbing the valve-lever operating gear and the fulcrum shaft.

To avoid long shutdowns of the engine, a spare exhaust valve with cage is kept on hand, which is slipped into the place of the one removed. The frequency with which exhaust valves have to be removed depends greatly on the nature of the fuel burned; fuels with high ash and coke content will foul the exhaust valves more rapidly. Although engines can be operated continuously for several weeks, the usual practice is to stop an engine for about an hour weekly, and remove the exhaust valve and fuel needle of one cylinder. The valves and needles of the other cylinders are removed in rotation each week. The valves are removed regardless of their condition merely to keep the engine at its highest efficiency.

When the scavenging valves of two-cycle engines are placed in the cylinder head, the four valves are operated in pairs; and each yoke (or valve pair) is actuated by a system of double rocking arms, so fulcrumed as to form a parallelogram which serves to actuate all four valves simultaneously and to open each valve an equal amount.

The time at which the different valves are opened and closed differs widely with different makes of engines.

The air valves open 10 to 20 deg. before the piston reaches the top dead center, and close 15 to 20 deg. past the bottom center, being open a total period of 210 to 220 deg.

The fuel valves open 2 to 8 deg. before the piston reaches the top center, and close 18 to 36 deg. after the piston has passed the top center, being open 20 to 44 deg.

The exhaust valves open 25 to 45 deg. before the piston reaches the bottom center, and close 8 to 14 deg. after the piston has passed the top center.

The angle of lead is least for slow-speed engines and greater for high-speed marine engines of moderate power (100 to 200 horsepower; 400 to 600 revolutions per minute). This angle makes allowance for the inertia of the valves; the type of fuel valve and the properties of the liquid fuel burned also influence the timing of the fuel valve.

(To be concluded)

FUEL OIL WASTE

THE Bureau of Mines and the Fuel Administration have sent a number of engineers into those parts of the country where fuel oil is extensively used to visit the plants and endeavor to demonstrate to the men where losses occur and how they can be stopped. As one result of the investigation a handbook for boiler-plant and locomotive engineers has been issued by the Bureau of Mines, giving instructions on the efficient use of oil fuel.

"I have always been aware that the United States, probably through her great richness of resources, is one of the most wasteful of nations, but it has taken the emergencies of the war to disclose with startling directness the colossal wastes of war-winning supplies that are still going on," said Director Manning. "It is a new chapter in national profligacy to learn that in its use we are wantonly destroying one-fourth of our supply of fuel oil, to the extent of 40,000,000 barrels a year, while our oil operators are directing every available energy and millions of dollars toward inducing the earth to give up more and more of the precious petroleum, the most perfect of existing fuels. Something more than criticism from a Federal official is called for when it is realized that in this greatest of world crises the very fuel which is greatly needed for our American Navy to drive it on to final victory is being dissipated here in this country to such an alarming degree."

The Motor Truck as an Aid to Business Profit

By S. V. Norton (*Non-Member*)

A COMPREHENSIVE and illuminating book on the use of the motor truck has recently been prepared by Mr. S. V. Norton. The title defines the scope of the work. It is written primarily for the business proprietor or manager using or contemplating the use of motor trucks. Many helpful suggestions on the selection and care of motor trucks, loading, unloading and routing are made. Very strong emphasis is laid on the necessity for accurate operating and maintenance cost records and many methods for keeping account of costs are described and illustrated by reproductions of typical forms for the use of drivers, repairmen, dispatchers and delivery superintendents.

The volume is in large part a compilation of records of experience and data obtained from manufacturers, associations, government agencies and other large users of motor trucks, and individuals.

The author has been closely associated with the motor truck industry from its inception. As manager of the truck tire sales department of the B. F. Goodrich Rubber Co., he has had many opportunities to study at close range the various problems of motor truck owners. The book is written as much for small as for large users of motor trucks. Much of the most valuable information in it is based on the experience of business men who operate but one truck. The author states that the objection frequently raised that one's business is "too small" for the employment of motor trucks is unsound nine times out of ten.

The subject of the use of trucks is also treated broadly in an able and forceful way. Mr. Norton shows excellent comprehension and vision of the economic principles involved and of the prospective development, as is shown by the excerpts from the work given below.

The volume is divided into five parts. Naturally there is a certain overlapping of topics in these different sections, largely owing to the various sources from which the material was gathered. An excellent subject index, however, guides the reader to all references on a given subject.

The chapters of Part I are under the general heading "Fitting the Motor Truck into Your Business," and cover the following subjects: Field of the Motor Truck in Modern Business; When to Change from Horse to Motor Delivery; Comparative Cost of Horse and Truck Delivery; How to Determine Cost of Performance; How to Keep an Effective Record of Costs; Selecting the Right Truck for the Work.

Extent of Use of Trucks

Before the close of the year 1918, there will probably be over 400,000 motor trucks in service in the United States. In less than a score of years the child has become a giant. But the giant of to-day will be considered a dwarf in comparison with the giant ten years from to-day. If the increasing output of motor trucks in the past decade is any indication of what the future will develop, we may expect in years soon to come to see a system of transportation which will number its units by millions.

Length of Haul

The condition most in favor of motor truck operation is one involving long hauls. In fact, it may almost be said that anyone having to make long hauls in his business should motorize at once without further debate, as the case for trucks is practically settled by the mere statement of this condition. In making long hauls the truck has a chance to show the speed which is half the secret of its efficiency. Even if the other half—the capacity for load—were entirely lacking and it carried merely the cargo of a single horse and wagon, it would still do the work of four or five horses, because it would operate from four to five times faster. Commonly, however, it has a good load to carry as well, in which case both factors of our formula, speed and load, are present, making the resultant product, "work," very high.

Transportation involving short hauls is the obverse of the medal, and as a general thing presents a condition unfavorable for the operation of motor trucks. The factor of speed is, of course, the most noticeably affected. In going short distances the truck has scarcely time to get up to high speed when it has to stop. Of more serious consequences than this, however, are the stops made to deliver goods. Frequent inaction, of course, reduces the average daily speed just as effectively as slow driving. It is worth noting, however, as the experience of many firms, that deliveries made to several points over three ordinary city blocks apart are just outside the classification of short hauls and often work to great advantage.

Time Element

The motor truck is comparatively expensive. It commonly replaces three or four wagons, and when it is standing still four horses are idle. It is capable of good speed and enormous loads. It asks for work, however, and when given its capacity it starts complacently away with a cargo which five horses could hardly stir, and carries it four times as fast. By doing these prodigies it can even stand idle in our horse-planned shipping rooms and freight docks, and still, out of the bounty of efficient performance when in action, declare the merchant a profit. Idleness, however, is a spendthrift waste, and one which should be eliminated.

Unit Capacity

The average traffic manager as yet feels no special pang when he sees his horse and wagon standing idle per-

Review of publication by A. W. Shaw Co., Chicago, 1918. Cloth. 6½ by 9½ in., 509 pages of text. Illustrated with 335 photographs and charts. Price, $7.50.

haps an hour before being loaded and another half-hour while being unloaded. Progress has changed all this. In the larger centers, where motor delivery is practically universal, we see traveling belts, gravity chutes and spiral slides, escalators for carrying heavy articles and various other devices for feeding the cargo to the waiting truck in a fractional part of the time in which a grocer loads his wagon.

If a given transportation problem involves the moving of widely variable loads, the most satisfactory solution is to be found in the use of trucks whose capacity is somewhat under that of the average load to be carried. Rather than employ units which can, in one load, carry away the accumulation of a day's freight, it is considered better practice to have two or three smaller trucks which keep busily pecking away, moving part of the merchandise, at the same time leaving a certain amount behind, like a balance in the bank.

If a man wishes to move four tons of reasonably compact merchandise it is, generally speaking, cheaper to use a single four-ton truck than two two-ton trucks. Where a load of definite size and weight can be depended upon, the most satisfactory course is to buy a truck to fit that load.

Items of Cost

What are those items, which, taken together, constitute the cost of motor truck delivery? The answer is:

(1) Interest, (2) Insurance, (3) Depreciation, (4) Taxes, (5) Garage Rent, (6) Overhauling, (7) Repairs, (8) Tires, (9) Driver's Wages, (10) Helper's Wages, (11) Gasoline or Current, (12) Oil, (13) Supervision.

The following table, furnished by a truck manufacturer, shows the cost of operating a one-horse and a two-horse team in Boston.

COST OF OPERATING SINGLE-HORSE AND DOUBLE-HORSE TEAM IN BOSTON

	One-Horse Outfit	Two-Horse Team
Driver's pay per day,	$2.00	$2.50
Feed per working horse per day,	.90	1.80
Rent and stable expenses per day per horse,	.31	.62
Shoeing and small repairs per horse per day,	.19	.38
Claims, accidents, tolls and so on,	.18	.36
Foremen's and jumper's pro rata per day,	.18	.36
Other helpers per horse per day,	.20	.40
Repairs, harnesses and painting,	.13	.26
Managers' or superintendents' salaries per day,	.10	.20
Office and telephone rent and clerks,	.31	.62
Miscellaneous, veterinary and the like,	.24	.48
Fire and accident insurance,	.08	.16
Depreciation for renewal of horses,	.20	.40
Total,	$5.02	$8.54

Owners of teams are much more prone to neglect the many "invisible" items of expense than owners of trucks. They assume that the expense of horse and wagon delivery is much lower than it really is, and consequently when the inevitable comparison is made between their present delivery cost and what it would be if they operated trucks, they delude themselves into concluding that motor truck transportation would be more expensive; whereas, if their horse costs were properly figured, the true conclusion in a vast majority of cases would show trucks to be the cheaper.

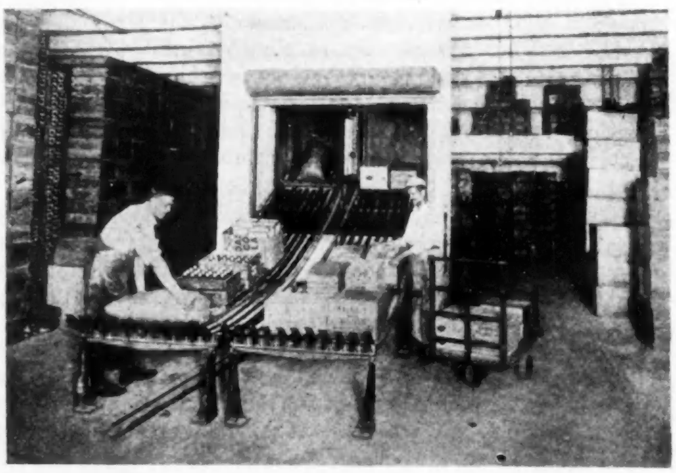
It must not be supposed that the cost of operating a five-ton truck, or any truck, can be represented by a definite figure. Costs vary in different lines of business due to different haulage conditions. One large truck maker, when asked to give specific figures on the cost of operating motor trucks of various capacities, frankly admitted it was impossible to do so. In his opinion, the operating costs of different makes of machines would vary, even though used in the same line of business and under identical haulage conditions. Here are his words:

"Fuel consumption alone may vary over a wide range and instances are recorded where machines of one make show a fuel consumption 40 per cent greater than that of another. Corresponding depreciation is in direct ratio to the quality of the machine and its life expressed in miles of operation, so that this item varies widely when applied to the motor truck industry as a whole.

"Another important item in motor truck operating costs is unnatural obsolescence caused by the manufacturer discontinuing business."

The Commercial Ton-Mile

Instead of the absolute ton-mile, the commercial ton-mile is generally used in computing motor truck performance. Here no notice is taken of the various partial deliveries of the truck load, inasmuch as this will be reflected more or less faithfully in the item of distance covered. The commercial ton-mile is computed by multiplying the load with which the truck starts out by the round-trip distance. If any load is picked up along the route, such, for instance, as a return load, commercial ton-mileage is figured against it precisely as if the truck were starting out again, with what is really a pickup considered as new load for delivery.



In the shipping room this device automatically discharges its loads upon chutes, where they are assembled for transfer to the truck. By its use a New York wholesaler assembled a 6-ton load from five floors in 35 minutes

In using the absolute ton-mile, it would appear that the truck was working only while it carried a load, and in figuring costs it would seem that there was a tremendous waste in having the truck return empty. Suppose, however, that the delivery problem is such that a one-way load only is possible, and that through no efforts in the way of replanning the delivery system can the fundamental conditions of the installation be altered. The return of the truck empty is as necessary a part of the delivery as the loaded trip out. The cost system should reflect that fact.

Cost System

A simple but complete cost system can be put into effect by the use of two forms only. The first is the driver's daily card, and the second, the monthly summary. These two forms are absolutely essential, but additional forms are often used in connection with them, such as tire record forms, gasoline tickets, and so on.

The driver's daily report card should

(1) Be made of tough manila cardboard, so that it will take rough or careless handling,
(2) Be punched with a hole reinforced like a tag so that it can be tied to the steering-wheel or other part of the truck, or
(3) Be small enough to fit into the driver's pocket or hat,
(4) Be as simple as possible consistent with furnishing the information actually required, and
(5) Be combined with an inspection report (generally on the back).
(6) It should give at least the following information:
  (a) Identification
  (b) Supplies
  (c) Trips
  (d) Tonnage or packages
  (e) Miles
  (f) Time
  (g) Weather conditions

The truck operator in calculating his expenses for the previous month has on the desk in front of him bills, vouchers and memorandums from the bookkeeper as to charges for interest, taxes and so forth. These with a pile of driver's daily cards are all the information needed for computing his truck expense for the month.

Part II, "Making Your Motor Truck Do More and Better Work," covers Planning the Delivery System Right; Devices that Reduce Loading Time; Effective Scheduling and Routing; Carrying More Goods with Special Bodies; Principles Governing the Use of Trailers; Using Trailers to Haul More Goods; Helping the Truck to Unload Effectively; How to Get the Cooperation of the Driver; Supervising the Truck by Mechanical Devices; Installing a Bonus System.

Planning the delivery system should begin inside the store, and the first step in working out the problem is to have the load ready when the truck is ready, and the right load for the right truck. It is possible under certain conditions to work out a schedule as fixed and dependable as a railroad time table.

A transportation expert who took hold of a fleet of 25 trucks belonging to a well-known Chicago wholesaler saved his firm $8,700 in a single year's operation by replanning the entire delivery system. Beginning with the arrangement of the trucks in garage, his plans affected every detail of the delivery system, even to the handling of C.O.D. invoices by the drivers.

Eliminating Piece-by-Piece Loading

By using demountable bodies in connection with four trucks one company made a gain of 14 tons a day in haulage, the work consisting in hauling mail bags. The method is as follows:

At the beginning of each day's work, four of the bodies are hung up at the loading platform at the plant, and all of the trucks are in the garage. Four-wheeled hand-trucks of one to one and one-half-tons capacity are used to convey the mail bags from the post-office checkers on the wrapping floor to the loading platform. Iron bridges between the platform edge and the tailboards of the suspended bodies permit the hand-trucks to be rolled directly into the bodies. In this manner the truck bodies are quickly and easily loaded, and trucks to haul them away are dispatched from the garage. Before they report at the shipping platform each picks up a load of paper rolls at the warehouse. These are transferred to the courtyard of the main plant. The paper is taken off, and the empty truck backs into the loading bay, directly under the loaded body to which it has been assigned. After it has been backed into position the platform men lower the body to it and detach the supporting chains.

An official of the company stated that the bodies cost but $165 each. He figured it would take six trucks with permanent bodies to do the work that four trucks with six removable bodies do, so that the arrangement saved the cost of two chassis outright, the extra substitute bodies costing but $330. To this must be added the cost of the chain-falls used to raise and lower them, and tracks upon which they travel.

Trailers are as serviceable as demountable bodies; they may be left at loading docks, they may be moved about on their own wheels, and their slightly additional cost over demountable bodies is easily offset by their greater carrying capacity and the fact that they do not require chain-falls and overhead tracks.

The nest body is divided up, each compartment arranged to receive a uniform bin or section. These sections are loaded in different parts of the store and brought by suitable means to the nest, into which they are loaded. The nest or skeleton is then ready to be rolled upon the body of the truck when it backs up for its load.

The principle underlying all this is clear. A container is provided, in which to assemble the various units of a shipment, whether it be an entire demountable body, a nest body, or good-sized trunks or hampers. Checking and rechecking is done at the time of assembling. The containers are locked or sealed and when the truck backs up the load is moved onto it. Despite the simplicity of this well-known device, many large firms are still loading their trucks piece by piece, checking and weighing each piece at the moment of loading, and thereby holding up their trucks an unnecessary length of time. In the dry goods business and others involving the handling of many small units, proper machinery must be set up in the shipping room to cause an endless flow or current in the great mass of merchandise.

Load Assembly Methods

Working with spiral chutes are belt conveyors. These are broad belts which carry articles horizontally across the store. Their office is to pick up the articles as they whiz from the chute, and convey them in a semi-leisurely manner before the eyes of sorters, routers and other clerks, who give them their final disposition. One other agent, the floor truck, is indispensable. Often material must be moved for which the belt conveyor or the telpher is not suited. Little roller boxes are then used. Where material is heavy or bulky, large hand-trucks running on four wheels are needed, and they often have a capacity up to 1¾ tons. Then again where lifting as well as carrying is essential, hand-lifting trucks are employed—an elevator mounted on a hand-truck, to expedite the handling of heavy material.

Lastly, to meet the final test, an actual power-driven truck is introduced, the doughty little industrial, having a carrying capacity up to two tons, which takes the abrupt grades often met with in moving material at docks or terminals, and which on level floors draws long trains of hand-trucks hitched together. These industrials are so compact in size and so powerful that they

are run into freight cars, pick up heavy loads and carry them directly to the waiting truck.

For loading small and uniform units upon trucks where the nest body or trunk system is not applicable, a device called a roller gravity conveyor is used. This is made long enough to reach from the shipping dock to a point just behind the driver's seat, and when the forward end of the truck has been packed the conveyor is withdrawn a corresponding distance. Thus it is adapted to packing the truck at all depths, and the shipper does not have to carry the material any farther than to the edge of the dock.

A truck owner in installing a system of operation for a fleet of trucks is in a position not unlike that of the railroad builder. He must, so to speak, lay down tracks over which his business shall travel, routes which will become more or less fixed, and determine in a large measure the amount of profit his transportation system will return. Like the railroad man, he must consider distance, density of traffic, mechanical obstructions, costs per mile and per ton-mile, possible future returns, schedules, performance, and a dozen other factors. He must assemble them and reason out the right course of action.

Zone the Basis of Delivery

The zone is the basis of the delivery system. Correctly designed the delivery system erected upon it will have small chance of failing. Without the zone it would be impossible to figure on the probable time of deliveries; scheduling would disappear; the dispatcher on the loading platform would not know what load to get ready next or what truck to count upon; trucks would return and find no work to do, or be obliged to carry away under or overloads. Moreover, without the zone cost of delivery could not be figured for special jobs.

It may take time to lay out a satisfactory zone of delivery, but this is well spent, for a well-designed delivery route, one which is symmetrical, serves the largest number of customers with the least idle time, makes use of the shortest cuts and does not cover the same ground twice, is as much an asset as the truck that travels it.

In actual practice, delivery zones are developed by experiments. With the aid of the map and the scale of distances the location and the number of customers to be served, preliminary routes are outlined, but the test of the zone is the time study. In fact the time study is to the route what the scale is to the map, namely, a means of measurement, dealing not in miles, but in idle time, loading time and time spent in stops.

Congestion in Traffic

A Jersey City coal dealer who had recently installed trucks soon realized that he was not making money. Coal prices had not changed, but he was barely breaking even in a trade that had always been good. Investigation revealed the trouble at once. His trucks instead of taking four loads each to Manhattan Island every day, were averaging only three. They were losing time in the line-up at ferry slips, where delays of one and two hours were not uncommon. They were making three trips a day while the price charged was based on four trips. It was in the fourth trip that the dealer's profit lay.

About that time a street traffic engineer was engaged by Jersey City business men to investigate the ferry schedule, and during the investigation valuable charts were produced, and the truck owner by revising his routes in order to avoid the hours when congestion at the ferries was at the peak, reduced his delays and was able to make the necessary fourth trip per day. Much the same problem is met with in street traffic, and the merchant who is laying out his delivery zones will find that it pays to get data on the congestion of certain streets and bridges during rush hours so that he can design his routes to avoid delays.

Road Selection

Often it is wiser to travel two or three extra miles in order to avoid a bad stretch of street. Here again the city usually has a record of streets closed or torn up. Wise shipping bosses keep all such information in plain sight, where the drivers cannot overlook it. One man keeps at the side of his desk a large-scale city map on which he marks with colored tacks and slips of paper the main thoroughfares and street intersections—white for those to be used, red for those to be avoided. A blackboard is also employed to bulletin especially bad road conditions as they are reported by drivers returning from their trips. Some owners issue positive orders that their trucks shall never leave the paved streets, and use their horses and wagons to cover the rough roads.

Amount of Load

Truck owners make more profits by carrying a uniformly greater load. That is, not an overload, but rather an avoidance of underload. Translated into terms of body efficiency, this means that motor-trucks are made more efficient by equipping them with bodies designed and adapted for the character of the cargo to be hauled. Different materials indicate in a general way the kind of body best fitted to carry them. Man's ingenuity goes deeper into the problem and produces special contrivances which expedite to the last degree the process of loading, unloading and carrying merchandise.

Trailers

Not only are there thirty-odd firms making trailers at present, but truck manufacturers themselves are turning their attention to this new phase of their industry and in some instances are preparing to build trailers. It is generally agreed that under certain conditions of road and grade the use of trailers may effect enormous economies. Business men everywhere are realizing that it is often more profitable to haul a load behind a truck than to buy axles, springs, wheels and tires big enough to support that load on the truck itself. The principle is sound—the only difficulty is in its application.

Two problems still vex the progress of trailer transportation. The first is: Does the practice of hauling trailers damage the truck? This may be answered at once by saying that it does increase the wear and tear on the mechanism of the motor truck. This is to be expected. But how much? Truck manufacturers, realizing the great economies often available by the use of trailers, are designing their trucks with a view to meeting the increased strains. They are providing larger radiators, larger brakes, larger tires and different gears, which will do much to solve this problem.

The other problem has to do with legislation. In some cities drastic regulations are being made seeking to limit or even bar the use of the trailer, because of congestion. Under some conditions such action is justifiable, but on the other hand it must be remembered that the trailer carries with it the brightest hope of reducing this congestion by lessening the number of trips. Street cars, in the rush hours, are coupled together and operated as

trailers. Truck trailers serve a like purpose. Moreover, the trailer brings with it the best promise for the maintenance of roads, for it distributes its load over many axles, and thus reduces the crushing total wheel weight, which is often a cause of serious damage to our highways.

Interchangeable Bodies

In connection with terminal delays, one of the best suggestions that has yet been made is the following: A type of standard body is made which will fit any three to five-ton chassis. These bodies are of uniform size and uniform value and are interchangeable. The terminal companies suspend these bodies from chain-falls, and when a truck arrives equipped with one of these standard bodies and a load that would naturally take considerable time or at any rate suffer a delay in the unloading, that truck is permitted to leave its loaded body at the terminal and take back an empty standard body in place of it. This scheme is being used successfully in Cincinnati, and is worthy of more extended application at other railway terminals.

A simple idea is back of this special body: why hoist heavy bales of cotton on top of the truck when it is much easier to carry them on side rails which are only a few inches above the street? The plan saves time and labor

Loss of Time

The American business man is accustomed to value his time in terms of money. He now has a rival, for not only is the time of the motor truck worth money, but it may be worth several dollars an hour. If it costs an average of $16 per day to operate a five-ton truck, the time of that truck is worth at least $2 per hour, but if it is figured that the truck which costs $16 is bringing in $40 a day, then it is proper to say that for every hour the truck stands idle the owner is suffering an absolute money loss of one-eighth of that amount, or $5. In fact, there are not very many business men whose time is worth more than the time of a five-ton motor truck. A good executive looks with concern upon anything that wastes five or ten minutes of his time, but if he does not take the trouble to investigate whether the time of his truck or trucks is being wasted, the aggregate loss may amount to a figure exceeding his own salary.

Bonus System for Drivers

The problem of getting the driver to take an interest in his truck will probably never be fully solved, but can be attacked with considerable success. The bonus system is the most direct way. Suggestions and instructions to the driver will help, but some kind of cash incentive is the trump card. The driver has an investment worth thousands of dollars in his care and keep. It is worth while to play a little game with him in which he will take an interest. The unique position of this almost free agent requires it, and the investment at stake justifies it.

Part III is headed "Maintenance that Lowers the Cost of Upkeep." The chapters of this part are entitled: What Underlies Sound Motor Truck Maintenance; How One Man Solved the Maintenance Problem; Saving Money Through Proper Lubrication; Why Overloading Means Bigger Repair Bills; How to Curb Overspeeding and Other Abuses; How Tires Can Raise or Lower the Cost of Upkeep; Selecting the Right Tires; Solving the Garage Problem.

Life and Maintenance

How long a truck will last depends upon quality, somewhat on the work it performs and the way it is handled, but most of all on the attention it receives, its monthly, weekly, daily, even hourly care.

The motor truck is urged on by explosions which occur thousands of times a minute. It is comparatively light, and when it encounters ridges, depressions, edges of bricks, car tracks, and thousands of other obstructions as it plunges over the road, it converts these shocks, together with the throbbing of its engine, into a ceaseless vibration which shakes every part of its mechanism, from the radiator to the tail-light. Is it any wonder that bolts become loose, that bearings wear, and that the moving parts of the engine require occasional tightening and adjustment?

In addition there is the transmission; the system for pumping and bringing water to the superheated sides of the engine; the clutch system; the lubricating system, sometimes involving a pump; the gasoline system, making use of the fine pipes and valves fitted to the thousandth of an inch, and the ignition system, employing scores of wires and using electrical instruments as sensitive and fine as any found in a jeweler's window. All these systems, with their various pipes, rods, gears, wires, valves and pumps must be attached to the motor truck and kept tight and in perfect alignment all the time.

The truck owner will do well to face the problem as it is. It need not cause him alarm, because he will see on every side trucks poorly cared for, yet giving good service for three, five or even ten years. Such is the staunchness of the modern truck that it will stand abuse which the first builders never dreamed of. But consider for a moment the additional years which can be added to the life of the motor truck by proper maintenance.

Inspection

Inspection is generally given once a month, but one fleet owner, who operates 19 trucks, sets his inspection dates 19 working days apart, and another who owns 40 trucks inspects two trucks every day. The small owner, who perhaps cannot keep a mechanic busy, requires an inspection of a much simpler kind, undertaken at frequent intervals.

A well-designed inspection report presents the important parts of the truck in logical order, either grouping them according to the system to which they belong, or listing them in the order in which they are reached by

the mechanic as he progresses in his examination from one end of the truck to the other. One theory holds that the periodic overhaul is a necessary supplement to any system of regular inspection. It is not practicable to inspect a truck once a month in a manner that will disclose every mechanical weakness. Moreover, it is often not practicable or economical to replace parts the minute they begin to show wear. This should be done at periodic intervals, such as every year, or every 10,000 miles. The other theory is that the periodic overhaul is illogical, inasmuch as it is an admission that certain mechanical troubles have escaped the regular inspections. It is contended that the monthly inspection should be so rigid as to detect every ailment at its inception. The determining factor is evidently the thoroughness of the monthly inspection. If the truck operator is equipped to give his trucks a rigid inspection at intervals of every few weeks, the periodic overhaul will become unnecessary and useless.

Maintenance Expense Record

The expense of maintenance, while properly appearing in the general budget, should be made the subject of a special accounting as well, for in that way the cost of repairs, replacements, adjustments, and so on, can be made to tell volumes regarding the delivery equipment which the merchant has selected, as well as to shape a policy for future purchases. It is obvious that the facts learned by keeping a maintenance record by months can be entered on a form covering a number of years, and in this way facts of a different kind will be brought to light. Tendencies which appear unimportant on the monthly record will stand out in bold relief on the yearly chart.

Status of Truck

More and more the motor truck is becoming understood, and is being assigned to its proper place in the field of transportation. It is neither a worker of miracles, nor an extravagant and unprofitable piece of machinery. It is a carrier with known possibilities, distinguished from the horse-drawn vehicle by its greater speed and power on the one hand, and its greater cost on the other. Under certain conditions it cannot economically replace the horse and wagon, but in most circumstances its greater speed and strength can be employed advantageously, so that a single truck may replace from 3 to 10, 20, or even 30 horse units. With the increasing knowledge of the truck as an efficient carrier has come a better understanding of its limitations as a piece of machinery.

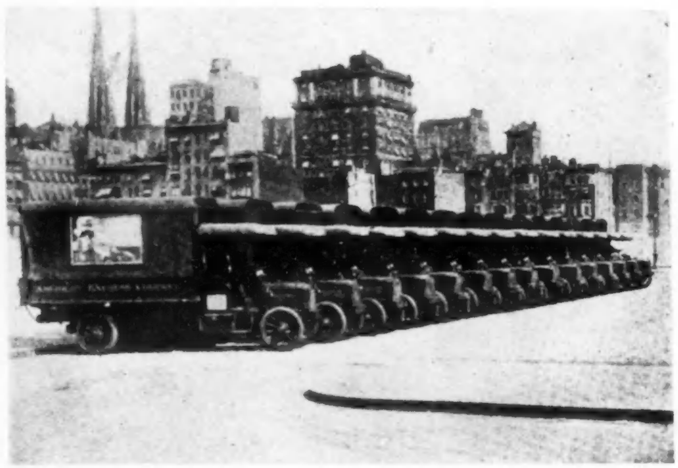
Factor of Safety in Design

A truck maker must design a truck that will deliver the most service for the money invested. This does not mean that the truck must be made as cheaply as possible. It means that strength and economy must be considered together. It will not do to build a truck enormously strong for the work intended, because a lighter truck, having a much smaller factor of safety, would handle the work just as satisfactorily and at much less expense. There comes a point where increasing the factor of safety does not pay—does not pay either the purchaser or the seller. Moreover, the designer must constantly work to keep down the weight of the chassis. This has been the constant effort of passenger car builders, and it holds true in greater measure for the truck maker. Extra weight means extra expense, both in selling price and operating cost.

There are conditions and combinations of conditions under which a truck five times as strong as those built today would be smashed. The designer despairs of building a truck that will stand overloading and overspeeding on rough roads. It is apparent that such a truck would be monstrous in weight, and extravagant in price. A factor of safety is provided because of man's confessed ignorance as to the precise effect of various strains and shocks. Tests of materials result in an average only. Factor of safety is the best guess we can make to provide for uncertainties.

Overloading

Again, factor of safety is computed with reference to the breaking point, but metal can be injured long before the breaking point is reached. Metal is subject to fatigue, in much the same manner as animal tissue. It can be worn out internally before showing any signs of strain on the surface. Thus drawing on the factor of safety, when it does not result in immediate harm,



What motor trucks mean to the express companies is only hinted by this fleet. It is about 1 per cent of the entire number operated by the American Express Company. Other express companies also use many motor trucks

is sure to cause a gradual and progressive damage which shortens the life of the metal by years. Moreover, it reduces the factor of safety. A piece of metal that originally had a factor of safety of six may, by repeated strains, be reduced to a factor of safety of four, then two, then one, then nothing. In that way a truck may fail with only a slight overload, or none at all, leaving the owner still to be convinced that there was no flaw in the metal.

To anyone claiming that a certain truck is guaranteed to carry half as much again as its rated capacity, a proper retort is:

"In that case the springs must be too stiff for the rated capacity and consequently must resist unduly the jolts and jars of the road, throwing greater strain on the axles and transmitting a greater shock to the mechanism of the truck. If they are correctly designed for the rated capacity, however, then this added load must have the effect of causing a greater stretching and compressing of the fibers of the spring steel than was ever intended, and although this may not cause an immediate fracture, nevertheless it must be wearing out the fiber of the steel at an undue rate that may have the effect of shortening the life of my springs by half."

Overspeeding

Overspeeding is a common abuse and perhaps fully as disastrous to truck life. Engineering problems which are simple when low speed is involved, become enormously difficult when an increased velocity must be reckoned with. This is why railroad trains running at 80 or 90 miles an hour have not proved a practical success. Anyone who rides a truck knows that when the speed is increased the vibration becomes very severe. This is due not only to the greater violence of the road shocks, but to the fact that the truck springs and in fact all parts of the truck cannot absorb the blows as fast as they are delivered, but receive them rigidly and transmit them unsoftened to neighboring members. There is no question that vibration is the most serious agent of ruin to which the motor truck is subject. It is a multiplication of the dreaded hammer blow, the most destructive force which can attack machinery.

Tires

It has often been said that the tires constitute the largest single item of expense in the operation of a motor truck. This is true for two reasons; not only are tires expensive in themselves, but they often have an important influence on the upkeep and performance of the truck—the work it will do per dollar expended. The heavy-duty pneumatic tire, which is still in the development stage, promises when perfected to revolutionize the design and performance of heavy trucks.

GARAGING

It has been proved that a firm owning a fleet of trucks, generally reckoned at eight or more, will do better by establishing its own garage. The reason goes back to the problem of truck maintenance. The care and maintenance of one truck does not justify the employment of a mechanic for that purpose only, neither does it warrant the purchase and installation of the equipment which plays so important a part in garage efficiency. One truck, however, presents almost the same range of mechanical problems as a fleet, and requires almost as much apparatus for its care. It is generally better therefore for the owner of one or two trucks to avail himself of the services of a well-equipped garage. Although he pays the garage proprietor a profit for his service, it is likely that he could not render that service to himself for less. On the other hand, the maintenance of a fleet of trucks may well keep one or more expert mechanics occupied all the time.

Supply Room

How can the supply room be kept in order? First, it should be kept apart from other activities in the garage. It should be considered a separate department, being charged with the goods it receives and charging other departments for goods which it delivers upon order. Second, its door should be locked and goods delivered only over a small counter. This prevents the garage workmen from helping themselves when the storekeeper happens to be away. Third, the parts should be arranged according to numbered bins, and entered on stock cards, by which the goods and the bins can be checked at any time. A simple stock card headed with the name or description of the part or material, together with its bin location, is kept. On the body of the card are spaces for the receipt of new materials and the delivery of material already on hand. A perpetual balance is kept, material coming in being added to and articles going out being subtracted from the previous balance. This single card form constitutes the "books" of the stockkeeper. The stockkeeper will not deliver material except upon receipt of a written order. The only order which he recognizes has a requisition number, which identifies it. Upon delivering the material called for, he enters the withdrawal on the stock card with the requisition number of the order. Thus he not only keeps a check on the material going out but identifies each withdrawal with the order which occasioned it.

Part IV, "Building New Business with Your Motor Truck," has as its chapter topics: Using Motor Trucks to Increase Profits; How the Motor Truck Can Help Meet Competition; Using Motor Highways to Reach Distant Markets; Making the Motor Truck Advertise Your Business; Increasing Profits by Cutting Delivery Costs.

THE MERCHANT'S TERRITORY

Generally speaking, a merchant is effective only so far as he can reach. Where wheels will go and return the same day is his territory. Beyond this is the territory of someone else.

If the merchant depends entirely on horse delivery, this circle is sharply limited to a radius of 10 miles, for it is universal testimony that the average team cannot with regularity and profit cover more than 20 miles a day. If he makes use of the motor truck the radius of this circle of effectiveness is increased to anywhere from 50 to 70 miles.

The merchant who seeks larger territory by the aid of the motor truck can call a geometrical principle to his aid. Roughly speaking, this principle is stated as follows: "Twice the Radius—Four Times the Area."

Years ago nobody would have thought that a baker would drive 40 miles to deliver bread. A Philadelphia baking concern, however, serves thousands of persons in outlying sections by means of 4 two-ton trucks. Two of these trucks average 98 miles every week day and another averages 97. In one month a truck will average 2470 miles covered, 780 stops made, and 117,000 loaves of bread delivered.

What made this tremendous expansion of business possible? Let us consider the following problem: If it were possible for this baking company to get fresh bread into the various little shops by the time they opened for business at 6 o'clock in the morning, this business would be theirs for the taking, as nearly everybody likes fresh bread for breakfast. The express company could not guarantee any certain delivery. Occasionally the expressman would be on time, but just as likely he would be late. When it comes to delivering bread for breakfast, a miss is as good as a mile, and bread that comes an hour late might as well not come at all. The trucks however could be operated on a schedule. They had nothing to do but deliver bread. They succeeded and this immense amount of business was created for the baking company.

Competition with Railroads

Railroads as a rule have been considered unapproachable as a means for hauling merchandise long distances over land. But it has become necessary to ask: "What is a long distance?" The distance between Milwaukee and Chicago is 85 miles. Is that a long distance? The freight rate is very low, being 37½ cents a hundred for

household effects, yet motor trucks make the trip regularly in competition with railroads. In Philadelphia an enterprising transfer company owns eight trucks of two well-known makes. With these trucks the company competes against the railroads to points as far away as Washington, Bridgeport, Conn., Harrisburg, Pa., and Dover, Del. It is not only able to compete in price up to a hundred miles, it has even exceeded that distance. Not long ago one of the five-ton trucks made a trip from Philadelphia to New Bedford, Mass., the round trip taking five days and the speedometer showing a distance covered of 710 miles.

Besides the feature of economy, the matter of time is often of great importance. People who move to distant places find it a hardship as well as an expense to wait for freight delivery anywhere from four days to two or three weeks, and on that account alone this transfer company has been able to compete against the railroads even when its charge was higher.

How is it possible for motor trucks to haul goods such distances as 50 or 100 miles in competition with a carrier as economical as the railroad? When your goods are in the box car which is rolling along over a smooth, almost level track, they are being hauled in the most economical manner known to land-borne commerce. Nine pounds of drawbar pull will move a ton of freight over level tracks. Five men can operate a long freight train. How can the motor truck, carrying a relatively small load and operating over all kinds of road surface, compete with such a carrier? The reason lies "at both ends of the route." Goods must be packed and crated, and carried to the railroad station. Then they must be unloaded, loaded on a hand-truck, then unloaded and put in the station, then loaded on the freight car—all this before the consignment begins its comparatively smooth journey to its destination. At the other end, the terminal, the consignment must go through a like process of handling, and finally be delivered to the consignee.

England, in her emergency, fixed the hard and fast rule that railroads must not carry freight within a zone of 25 miles from the center of such cities as London, Liverpool and Manchester. That meant that goods shipped inside the 25-mile zone to other points inside that zone had to be transported by motor truck. Similar embargos were placed on certain Eastern cities in this country, such as New York and Philadelphia. The three largest express companies sent out to their patrons a circular requesting that motor trucks be used for the shorter haul traffic in and around congested districts, and that only such shipments for near-by points as actually demanded express service be offered to the express companies, so that the traffic requiring expedited service to and from the distant points might be cared for.

Good Roads

Long distance hauling, already a proved success in hundreds of instances, brings the truck owner face to face with the problem of good roads. The lack of good highways connecting important points seems to be the only limitation on the indefinite expansion of long-distance trucking.

We have in this country over 2,300,000 miles of roads. Of this mileage only 10 per cent deserves the name of roads, and only a little more than 1 per cent of these roads is so constructed as to stand motor truck traffic the year round.

A system of connected and coordinated highways does not exist. The fleet of army trucks that made the run from Detroit to the Atlantic seaboard encountered many serious difficulties. Although the route lay through a highly developed region, and passed through several important cities, it was necessary to spend months in planning it, in investigating reports of road conditions, in building gaps in the proposed road, and in repairing and strengthening such parts of the road as were passable for trucks.

Road building is a long and expensive process. The distances in this country are so great that it would be impossible to connect all the cities and towns with suitable roads in a score of years. And what adds to the difficulty is that roads suitable for motor truck traffic are expensive, costing between $15,000 and $20,000 per mile. The motor truck has made new demands on the road builder. A motor-truck highway, to be worthy of the name, must be hard-surfaced, have a concrete base from 6 to 10 in. thick, and a minimum width of 20 ft.

Part V, on the general subject of "Present Tasks and Future Problems," is divided into three chapters entitled: How Motor Truck Associations Help Truck Owners, How to Meet Unreasonable Legislation, and Problems of the Future.

The motor truck is playing an increasingly important part. It is fast becoming a rival of the railroad in the transportation of freight for relatively short hauls where highways are suitable, and for this service it possesses the notable advantage of door-to-door deliveries, thus avoiding and helping to decrease terminal congestion.

By operating the terminals independently, night and day, either under private control or contract with the railroads, or perhaps under Government supervision, which would of course necessitate the cooperation of shippers and receivers of freight at the principal railroad terminal points, the tireless motor truck, with a sufficient number of shifts of men, would make it possible to keep this highly important process in operation practically without stopping.

Water Routes

There is no doubt that much non-perishable freight might be moved by boat on rivers, lakes and canals more cheaply and quite as suitably as by rail. The national policy of Germany in this respect for the past 40 years affords a striking example of what can be done to keep down the cost of transportation, through the development of inland waterways, on account of both the low cost of water transportation and the competition it develops with railways. If this, too, is developed in the United States, as a national policy, motor trucks will play an important part at shipping and receiving points, since they can cover effectively an area of tributary territory having a radius of 50 to 75 miles, provided they have fairly good roads and average weather conditions.

Control of Oil Industry

AT a conference held recently in Tulsa, Okla., and attended by producers and refiners of oil, M. L. Requa, general director, Oil Division, United States Fuel Administration, described the relations of the government and the petroleum industry. Mr. Requa's address is given in part below.

"In order that you may realize exactly what I have in mind, it is my purpose to explain somewhat in detail this problem as it presents itself to me. I take it that it is needless to go into any explanation of the vital necessity for petroleum products in winning this war. *This war cannot be won without the products of petroleum,* and I can conceive of no prouder position in the ranks of our national defense than that occupied by this great industry which supplies the lubricants for the machinery of our national industrial life, the fuel for our great battleships and for our fleets of airships.

"No industry has been more completely or more effectively organized for war work. The National Petroleum War Service Committee has made possible results that could be reached in no other way. Stabilized prices for the Allies have been agreed to, the orders all placed among the industry with an agreement that the smaller refiners may have more than their proportion if they want it, and an agreement, on the other hand, by the large companies that the quantity will be forthcoming as needed.

The National Committee and the subcommittees are pre-eminently volunteer organizations formed for the purpose of placing the combined resources and activities of the petroleum industry most completely and efficiently at government command for war needs. It has an important function to perform in the matter of fair prices. The knowledge of its members freely given to the government for the asking is of greatest value. The National Committee and the subcommittees deserve, I am sure, the confidence not only of the industry, but of the Fuel Administration as well. I shall expect that in all vexatious problems, disputes and trade adjustments, the industry will endeavor to govern itself and reach a satisfactory agreement either independently as between the parties interested or with the aid of the local committees; failing that, then through the good offices of the National Committee, appealing to Washington only as the last resort after all the suggested means of settlement have been exhausted. Centralization of control in Washington as to the details of the industry is hopeless if we are to have the greatest efficiency and exertion of the maximum effort.

"Is the oil industry unique or exempt? Does it seek for itself the right to go unchallenged and uncontrolled? I confess that that is not my conception of the spirit of the industry. The proposal I am making is that stabilized differentials be created as between crude petroleum and finished products at the refinery, and as between refinery prices and the price to the ultimate consumer; that these differentials be maintained and move in unison with the price of crude; that if necessary the volume of business be frozen and new business equitably distributed; that the old theory of competition give way for the war period to a condition of mutual helpfulness in behalf of national welfare, and that all these things be brought about by the *voluntary* action of the industry in harmonious co-operation with the Fuel Administration.

"The present discussion will not go into the question of the price of crude. That price should be eminently satisfactory to the producers. Certainly, never before in the history of the industry have they received profits equal to those now being gained. New development is active, production being more than maintained, and from the viewpoint of national need there is no valid argument to be made in behalf of increased prices. Our discussion has to do with the subject of premiums to be paid above the base price for crude of superior quality. It is not to be understood in any sense as an order to pay premiums, but simply as an inquiry—a request—to the industry to determine the amount of premium a refiner may pay, if he so elects, without subjecting himself to criticism. I have presented no plan, but have simply asked that the industry for the national welfare determine a method that will most satisfactorily accomplish the desired result. I am here for the purpose of discussing with you the reason for this request and to ask you to determine what method will in your opinion be most satisfactory. In approaching the subject, I ask that you keep in mind the abnormal conditions that surround us, and that you remember we may no longer apply old standards of measurement, but must surround ourselves with the atmosphere of war and use the national necessity as our measuring stick.

"The problem of petroleum is not a domestic problem, but is one which vitally concerns not only the welfare of our American soldiers and sailors but the welfare of the Allies also. So instead of a national problem only, we are confronted by an international problem that concerns the petroleum supplies of the world—the delivery to England, France and Italy of the largest part of their needs for petroleum products—and I am perfectly sure that when the history of these times shall have been written there will be no brighter page than the one which tells of the triumphant success of your industry in meeting every call made upon it for its different products, and of its having so governed itself as to deserve the highest praise for its patriotic devotion and demonstrated ability to rule itself wisely and conservatively—a triumphant vindication of the principles of democracy.

"I cannot believe that the oil industry comprehends how utterly helpless it would be at this time without the services of this department. The war program is of such magnitude that it requires the entire iron and steel output of the Nation, and many other commodities are to greater or less degree requisitioned for government use. To care for this condition there has been set up in Washington a committee known as the Requirements Committee of the War Industries Board. The function of this committee is to allocate among various industries the products of our industrial world. Without this allocation, and without the accompanying priorities from the Priorities Committee, it would be impossible for the petroleum industry to secure the necessary supplies used in producing petroleum; and yet the plea is made that the petroleum industry should be let alone. Let alone to what end? To fail miserably in discharging its obligations to the government?—because that failure *would*

follow without the necessary supplies, procurable only through government assistance.

"It is true that many companies have large stocks of supplies on hand; it is true that the industry as a whole has been raking over its old material, and utilizing second-hand machinery and pipe as never before; and it is equally true, in the opinion of the Director of the Oil Well Supply Bureau of the Oil Division, that the end of these resources is in sight, and that in the near future the activities of the Requirements Committee on behalf of the Oil Division will assume an importance of first rank.

"It would have been a simple matter under the provisions of the Lever Bill for the Fuel Administration to fix differentials and to announce those differentials under the authority conferred by that Act. There could have been no successful objection; the oil industry would of necessity have been compelled to follow those rules and regulations. I am, however, convinced that before promulgating such rules the men most interested should be given opportunity to meet face to face with the government officials charged with supervision of the oil industry, for the purpose of frank discussion of the reasons for making some such control desirable.

"I realize that it is not possible for the producers of oil or the refiners of oil in Oklahoma to be fully acquainted with the many problems confronting official Washington. The magnitude of the struggle in which we are engaged is, I think, but faintly comprehended even by many of those who occupy official positions. The most profound students of military tactics in Europe failed at the outset of the war to visualize in any degree the gigantic proportions that the conflict has assumed, and it is recorded that after the battle of the Marne the German General Staff, realizing how utterly it had misjudged the course of events or the immensity of the undertaking, deliberately set to work to construct an entirely new theory for the conduct of future warfare. And if those men could not pre-visualize the task, how can you men of Oklahoma, far removed from the strife, gain any real comprehension of the titanic struggle in which this Nation is involved? It is because of the inexpressible extent of conflict, because it is a life-and-death grapple between Autocracy on the one hand and Democracy on the other, that it behooves us to leave unfulfilled *no* endeavor that will make for Victory; and this without the possibility of compromise; with the certainty of untold sacrifice, even unto the death of those we love best, and in full knowledge that we *must* pay the price; but sustained by the serene conviction that out of all the chaos and warfare shall rise, clear-shining and triumphant, the abiding glory of Liberty and Freedom for all mankind.

"In the accomplishment of our great task we have been called upon to supply materials in undreamed-of quantities. The building program of the United States Government for the year 1917-18 exceeded the entire building program of the American Nation in any year prior to our entrance into the war. For every soldier in France it has been estimated that we must supply five men to serve in the industrial army at home which must keep our Army and Navy thoroughly equipped with arms, ammunition, food, clothing and endless other supplies. For every five torpedo boat destroyers scouring the coasts of England and France in search of the U-boats, one tank ship must be kept constantly in transatlantic service to carry to them their supply of fuel oil. For every thousand airplanes circling like avenging eagles above the ranks of the unspeakable Hun, the oil fields of the United States must *daily* supply between 2000 and 3000 barrels of gasoline. A single order from the Navy for 50,000,000 feet of wire rope is matched by one from the Army for 10,000,000 pairs of shoes; from the Shipping Board for 1200 ships; and from the Food Administration for meat products to the value of $200,000,000 per month to feed the armies and navies of America and the Allies.

"At this time of crisis the producer, the refiner, the jobber, the Standard and the independent must recognize the other's rights and respect those rights, working as a unit. In following any other procedure you will discharge less than your obligation to your country. You men may no more choose your own path in these days than may the soldier in France or the sailor on the high seas. You are obligated to do your part quite as solemnly as they; and that obligation can only be fulfilled by the most perfect, complete and harmonious unison of action. We may not have civil war, in the form of unrestricted competition, at a time when we are fighting a great war on foreign soil."

WORK OF DEPARTMENT OF LABOR

THE Department of Labor, the youngest in the Cabinet, was founded for works of peace, but immediately after its conception the scope of the department grew in the endeavor to carry on the simultaneous task of increasing production and improving the efficiency and condition of war workers. In an address recently made at New York, Secretary W. B. Wilson stated that his department now has eight divisions for the carrying on of its work. These divisions consist of:

1 The Adjustment Service, formerly known as the Division of Conciliation, which seeks to bring about an adjustment of labor disputes on terms mutually acceptable to employers and employes, and which works in conjunction with the National War Labor Board. The function of this organization is to compose questions at issue between employers and employes where adjustments have not been reached through the machinery of existing agreements or law.

2 The United States Employment Service, the work of which has already been outlined. There are Bureaus of Labor Statistics, Immigration, Naturalization, Industrial Housing and Transportation and Children.

Divisions have been created to cover Information and Education, Conditions, Labor Service, Women in Industry Service, and Training and Dilution of Service.

A War Labor Policies Board cooperates with the other divisions of the department.

In a word, the Department of Labor is that part of the Government which deals with intimate human relations, the inner American life. Other departments are established to look after foreign relations, national defense, finances, laws, farming, mails, patents, public laws, and commerce.

The Department of Labor represents no one element. It deals with the relation of all elements of our internal industry. American life is American industry; practically none of us is outside of it; hence this department stands for all of us, its purpose being the harmonious progress of home life and business life.

"What do you earn? Where do you live? Who are your neighbors, and who will be your neighbors next year? Whom shall we admit as immigrants, as citizens? What kind of people do we need? How can we adjust disputes?" These are its problems.

Transantlantic Flight*

IF today our object were merely to cross the Atlantic, this could most assuredly be accomplished with any of the giant flying boats which during the past year have been developed by the British Government. Machines like the F-5 or the Porte boat would be able to make the trip with only one refilling during the journey, if the flight were made during the most favorable weather conditions.

Routes

The direct or all-British (A. B.) route, which is, geographically speaking, the shortest, leads from Cape Spear, near St. Johns, N. F., to Valencia Island, Ireland, and involves a non-stop flight over the Atlantic of 1923 miles.

Of the two other routes, affording intermediate points of stoppage, one, which we shall call the Northern, would lead from St. Johns, N. F., to Christian Sound, Greenland, thence to Reykjavik, Iceland, and from there to Lewis Island in the Outer Hebrides. The total distance of this route is approximately 2300 miles; that is 20 per cent longer than the A. B. route; only, in lieu of a 1900-mile overseas flight there would be three laps of 940, 730 and 635 miles, respectively.

The third route, which may be called the Southern, leads from St. Johns, N. F., to the Azores, and thence to Lisbon, Portugal. The longest overseas flight on this route amounts to approximately 1200 miles, on the leg from St. Johns to Flores, the westernmost of the Azores, whence there would remain a short leg of 310 miles to St. Michaels, the easternmost of the Azores, and one of 850 miles from St. Michaels to Lisbon. The total flight distance of the Southern route would thus amount to 2360 miles.

Political considerations are distinctly unfavorable on the Northern route, and are not entirely satisfactory on the Southern route. The Northern route involves points of stoppage lying in territories belonging to the Danish crown, namely, Greenland and Iceland. Though it may be taken for granted that our transatlantic airplanes would carry no offensive armament, and should therefore possess the status of merchantmen, it seems more than likely that Germany would send strongly worded protest notes to Denmark should British aircraft use Danish soil for refueling, in view of the fact that our machines would be manned by military crews.

A somewhat serious drawback may be found to the Southern route owing to the fact that our airplanes on arrival in Portugal, would have to complete an additional overseas flight of some 800 miles in order to be delivered on British or French soil. It would obviously be the proper thing to fly our machines from Portugal to France in an air line rather than have them take a circuitous route via the British Isles or Brest. Unfortunately, the strict neutrality of Spain would more than likely interfere with our flying aircraft across her dominions.

Therefore, unless we accept the handicap of flying our machines from Portugal to Great Britain or France, the Southern route seems rather out of the question as a practical proposition. If it should, nevertheless, be chosen, then a switch line might be introduced at the Azores which would lead from St. Michaels to Vigo, Spain; the overseas distance of the third leg would thereby be increased to 927 miles, but the total distance to be flown to British soil would be shortened materially, and amount to 576 miles, with a longest overseas flight from Cape Vilano, Spain, to Ushant Island, France, of 413 miles. This was the route Lieut.-Col. Porte, R. A. F., proposed to fly in 1914. The total distance from St. Johns to Plymouth, England, would, over the Southern route, then be 3013 miles.

Meteorological Conditions

If one considers that a following wind of 20 miles per hour would add 480 miles to a day's flight, the importance of possessing a precise knowledge of the meteorological conditions which prevail in the Northern Atlantic becomes self-explanatory. Over an ocean area of twenty degrees there is a more or less constant southwesterly drift of air, which would naturally be instrumental in increasing the independent velocity of our machines flying from America to Europe, and would be correspondingly unfavorable to a flight in the opposite direction.

The intervening miles of sea are peculiarly susceptible to great eddies of wind and rainy or snowy weather, sometimes extending as much as a couple of thousand miles in diameter. These cyclonic storms move up from the Gulf of Mexico. On one course one-half of the prevailing winds blow from a westerly quarter with a speed of 21 m. p. h., while on a second course three-fourths of the winds blow from the same quarter at the rate of 28 m. p. h. These wind velocities were obtained by proof by the late Prof. L. Rotch on correcting the data of the Pilot chart of the North Atlantic for July to the level of 1000 meters (3300 ft.) by the average change in velocity and direction of these winds as found at the Blue Hill Observatory.

The A. B. route would have the great advantage of being situated within the area of maximum intensity of the eastbound Atlantic storms, whereas the Northern and Southern routes would lie only on the fringes of this cyclonic belt.

Another factor of the problem is furnished by the vast fog bank which exists in the summer months over Newfoundland Bank for a distance of about 300 miles off shore. While the vertical depth of this fog bank is unknown, one may assume that its extent is not such as to prevent airplanes from flying through and over it without expending an undue amount of gasoline in climbing. Nevertheless, I believe it advisable that our transatlantic airplanes should avoid the area of this fog bank so far as is feasible. A machine heading for Ireland should steer for a hundred miles or so a northeasterly course on leaving Newfoundland. If such a course were steered at a certain altitude it would not materially add to the flight distance to be covered because the higher the altitude the more the wind tends to turn to the right, owing to the rotation of the earth.

Pilot Cutters

To prevent the airplanes from drifting out of their course it would be entirely sufficient to establish along the A. B. route a chain of suitable vessels (pilot cutters) cruising every 100 or possibly 150 miles from Newfound-

*Frithiof G. Ericson, M. S. A. E., in *Aviation*

land to Ireland. Since the direction finders now in use on allied and enemy aircraft have an effective range of 150 miles at the most, the transatlantic airplane fitted with such an instrument should have no particular difficulty in keeping in constant touch with the pilot cutters and receiving radio directives from the latter. They would also serve the valuable purpose of assisting in saving the crews of such machines as might have to alight on the Atlantic on account of engine failure, and possibly of salvaging the most important part of the airplane.

The Airplane Required

It might seem that a large seaplane fitted with a convertible undercarriage would afford the most promising solution for crossing the Atlantic, for such a machine could be fitted with floats for the overseas journey, and, having reached its destination, its undercarriage could be converted for overland use. It is unfortunate that the flying boat, though it possesses much greater seaworthiness than the float-type seaplane, cannot at present be considered in our plans, for two reasons: First, the ratio of total flight weight to useful or disposable load of the flying boat is considerably inferior to that of the float-type seaplane. This is due principally to the weight of flying-boat hulls for ocean service. It is obvious that the carrying capacity of the airplane would have to be taxed to the utmost limit, and that every pound saved in the weight of the structure would increase accordingly the flight endurance of the machine. While a well-designed land-going airplane will carry as much as one-half its flight weight (fully loaded) in disposable load, flying boats are seldom capable of carrying a disposable load much in excess of one-third the total weight.

Secondly, the structural features of flying boats being fundamentally different from those of land-going airplanes, it would be well-nigh impossible to convert flying boats for overland use; this would naturally defeat the main purpose of our plan (*i. e.*, the supplying by air of powerful bombing squadrons for use against Germany and Austria) and limit the usefulness of our cross-Atlantic machines to the function of acting as auxiliaries to the Allied naval forces.

The seaplane has the advantage of affording a materially greater amount of safety to the crew on water. An ordinary land-going airplane, on the other hand, would obviously sink in a very short time in water.

However, in selecting the float-type seaplane as the type of machine most desirable for crossing the Atlantic, it should be borne in mind that the floats of the seaplane undercarriage constitute a material item of weight, so that the all-around performance of such a machine must perforce be inferior to that of an airplane fitted with a wheeled undercarriage. As far as the disposable load of float-type seaplanes, particularly larger types, is concerned, this is somewhere between that of the flying boat and of the land-going airplane; that is, about 35-40 per cent of the total flight weight. It would, therefore, seem advisable to dispense with the floats entirely, if this could be done without putting in positive jeopardy the safety of the aviators, and rather seek a solution tending to make a land-going airplane capable of floating a certain length of time.

This might be achieved by fitting the undercarriage and the tail with bags made of air-tight cloth, which could be inflated from bottles of compressed air carried on board, and operated from the pilot compartment. Should the pilot be compelled to alight on the sea, the air bags would keep the machine afloat for a sufficient length of time to enable the crew to be rescued by the pilot cutters.

Such an arrangement will be found hard to dispense with if either the A. B. or the Southern route be adopted for crossing the Atlantic, because the greatest flight endurance that can be incorporated in a machine is still so limited as to require a very careful husbanding of all non-essential weight.

Number of Engines

That the cross-Atlantic airplane should be fitted with more than one engine is self-evident on considering the possibility of breakdown, which may occur with the best available engine. Two-engined airplanes do not seem a very desirable type for crossing the Atlantic because of the unfavorable aerodynamic features involved in flying such a machine on one engine only. Indeed, if a mechanical breakdown, or the necessity of saving fuel, should compel the aviators to fly part of the journey on one engine only, the off-centered pull of the running engine would require a corrective setting of the rudders, which would cause an appreciable increase in drag and a corresponding slowing down of the flight speed. It seems that the three-engined airplane offers the ideal solution of this problem. Such a machine might be fitted with either two eccentric tractor screws and a central pusher screw (like the Caproni biplane, for instance), or with two eccentric pusher screws, with the engines in separate housings, and a central tractor screw fitted on the nose of the main body. With this arrangement, by cutting out any one engine the power would be reduced but one-third, as against one-half for the two-engined machine, while if either eccentric engine were cut out the off-centered pull would be reduced in the same proportion.

In a four-engined machine, the location of the engines is a more difficult matter. As a development of the advantages resulting from the principle of having an odd number of engines, one conceives a five-engined airplane having three tractor bodies, which would carry the tail plane and two pusher bodies fitted in between. The greater splitting of the powerplant into independent units would naturally increase the value of this scheme, though there would be also a certain increase in dead weight, as well as in body drag, due to the existence of five independent bodies.

Crew

The crew should be made up of not less than four men. Two of these should be pilots and expert navigators, while the others should be air mechanics familiar with wireless operation; since the pilot who flies the machine could not attend to both navigation and wireless efficiently, and the other pilot should rest until the time of his "watch." It seemed highly desirable to have two wireless operators on board, so they may take their turn at the key.

Flight Endurance

In the most delicate part of the project, namely, the determining of the maximum flight endurance of a theoretical airplane, there are only two fundamental factors: the efficiency of the airplane as a whole and the efficiency of the air screw.

To determine the efficiency of a theoretical airplane as a whole, one must resort to empirical methods; that is, determine the efficiency coefficient of a great number of successful machines and then take the average obtained

for a given type. Following this rule, it will be found that the maximum distance a theoretical airplane can travel on its own fuel is approximately 1200 English miles.

Conclusion

The foregoing considerations lead to the following:

(1) The political and meteorological factors are most favorable on the A. B. route, and, in order of merit, less favorable on the Southern and Northern routes.

(2) Given the present aerofoil and air-screw efficiency, it appears impossible to build an airplane that will have a flight endurance greatly in excess of 1200 English miles. The aerodynamic factor is therefore distinctly unfavorable on the A. B. route (which requires a non-stop overseas flight of over 1900 miles).

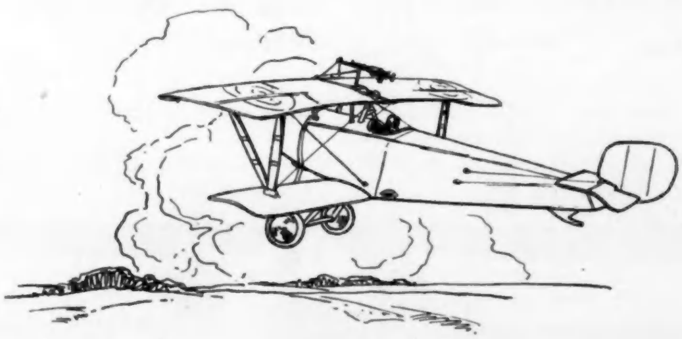
(3) If it is, nevertheless, intended to send the airplanes across the Atlantic over the A. B. route, the best way to achieve this is by using land-going machines fitted with floating bags in connection with specially constructed aerodrome ships of very large size, and capable of keeping station under their own power.

(4) The plan to create aerodrome ships and maintain them permanently in mid-Atlantic would naturally involve a very considerable expenditure, while it would not absolutely insure the success of the undertaking. Though it might prove easier to land on such a ship, with a moderate sea, and then take off similarly, in a storm the landing difficulties would be greatly increased, though they would surely not approach those that might be encountered on attempting to alight with a flying boat in an Atlantic storm.

(5) Should the plan to construct one or two aerodrome ships be favorably considered, one might observe that the ships should be fitted with Diesel engines of sufficient power to develop a speed of 5-6 knots; this should enable them to keep station in most weather. Using two hulls joined together by a platform, somewhat in the style of a catamaran, would most likely prove successful. The platform should offer a landing area of at least 600 by 150 ft. clear, and the ship should be protected against submarine attack by suitable armanent and possibly a number of patrol boats as well as scout planes. The last-named might also be of great assistance in finding lost or disabled machines.

(6) The maximum flight range of a practicable airplane, 1200 miles, corresponds approximately to the longest overseas journey required on the Southern route. By throttling down the engines in proportion to the lightening of the airplane due to fuel consumption it should be possible to extend the flight range by some 150 or 200 miles, so that a certain safety margin would become available to take care of incidental detours due to fog, storms, etc. It should, however, be noted that this margin is rather small to insure the success of a regular airplane route across the Atlantic.

(7) If the Northern route were chosen, it would seem materially less difficult to insure success. Heavy storms would constitute a much greater problem than fog; low visibility must also be taken into account. But since the storms blow mostly from a western quarter, and no flight should be attempted without careful weather forecast being available, the drawbacks of this route are more apparent than real. Low visibility should not prove an unsurmountable obstacle, since navigation would be by compass. A real source of danger might be the violent upward and downward gusts, and cyclonic whirlwinds. Against all these drawbacks one must consider the asset of the longest overseas distance, which amounts to only 940 miles, wherefore the theoretical airplane here considered would have a safety margin of over 33 per cent. This fact outweighs in my estimation the various objections that may be made against the desirability of the Northern route.



IN A CAPRONI OVER NEW YORK CITY*

EVEN with the ears stuffed with cotton, woollen helmets over them and leather helmets over all, the roar of the first front engine at our very ears was a tax on the eardrums. It sputtered into activity with a burst of flame and within a few minutes the two other engines, completely surrounding us, became active and vibrated the entire airplane.

The loudest bellow of conversation was a total loss, and in the midst of a cramped effort to cheer each other up and shout encouragement the signal was given and the great craft started to roll at lightning speed on its trip over New York City.

There was a rush of freezing air to indicate progress, and without any of the usual spiral to attain height the big machine turned her nose straight up and began a climb of 4000 feet into the air. Occasionally she would swoop forward as if there were danger of a turn backward, and after what seemed approximately two centuries and a spring she would straighten up and the knees which were gradually becoming crippled lessened their tension.

In front a big, black exhaust pipe poured forth a repeated gush of smoke, now and again intermingled with flame. My eyes traveled all about through the narrow strut work and the seemingly tiny wires which hold this monster together, and then, assuming that the fire risk was negligible, it seemed time to look down and learn how our party of twelve had progressed.

Away down through a space crossed only by a single tiny wire was to be seen the even countryside of Long Island. It seemed to be the merest doll's map, and there was not a sign of activity from end to end of one's range of vision. The great plane swung in some direction or other and it seemed that this vast and orderly landscape moved up along the side of creation and placed itself directly in front of me. Looking down through the same wire-obstructed aperture a glare was seen which proved to be the sun. We felt no inclination to find out what position the airplane was in. Instead, it seemed much more sensible to hunt a certain button on the cuff of the leather coat and play with it intently.

After a few moments of this entirely mirthless play I peeked out straight over the side of the machine again and saw nothing but the sky. That was perfectly satisfactory, and again looking down at the wire beneath me I was overjoyed to find that the placid green of Long Island was down where it belonged again.

I looked at it until it sudenly vanished in what appeared to be snow. We were over a cloud and below was nothing but fleecy white, while in our stratum the sun was shining clearly. As far as the eye could reach were the clouds, resembling snow-capped peaks, and from no angle was there a sign of land or space. It was exclusive but baffling, and when this situation was at its height the big Caproni suddenly turned its nose straight up again and we began a climb which lasted less than five minutes. It seemed as if the tail of the machine must be pointing directly at the concealed earth and again I felt the fear, born of inexperience, that the machine would topple over backward.

Suddenly we straightened, and, looking again without stirring, I saw through the wire hole below me that we were passing the end of a green colored outline of earth and that the black of water bordered it. It was New York Bay.

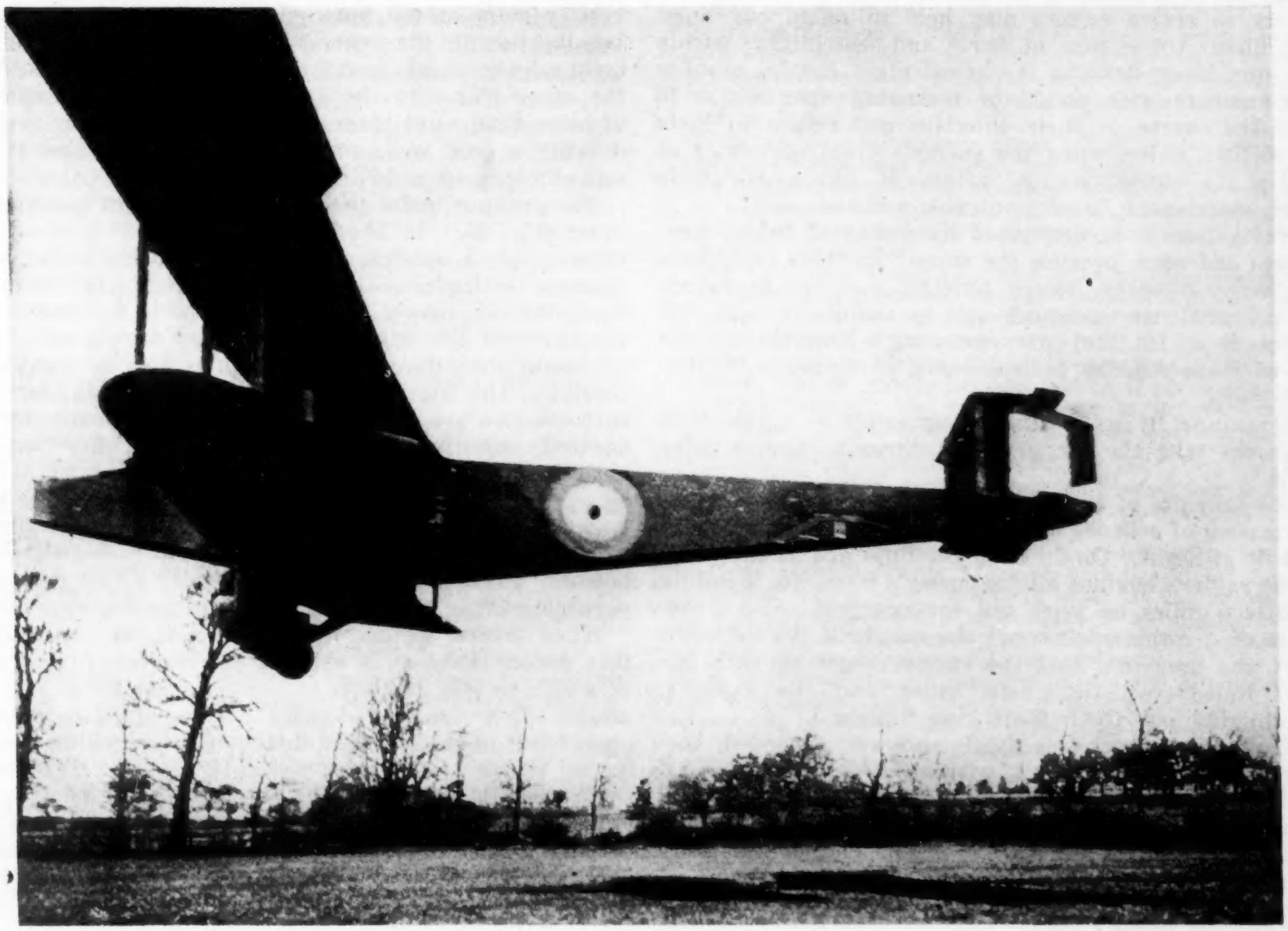
At that time we were at an altitude of nearly 6000 feet and the great shock of the entire air voyage then developed. The roaring engines at either side of me suddenly stopped. I could not see the aviator because one of the other passengers was between me and the two officers. None of us knew whether the stopping of the engines at this height was intentional or in fact whether in the roar of the third engine the pilot was aware that two engines had stopped. Suddenly the nose of the Caproni turned abruptly down, and as the third engine died out we glided nearly 2000 feet toward the shores of Battery Park. The earth fairly raced to meet us, and it seemed that the pilot was to attempt a landing, which we had been informed was one of the dangers of flight unless landing conditions were ideal. We had no notion whether there was anything ideal about landing in the water.

Just when it seemed advisable to start to rip off eight or ten garments in preparation for the swimming stunt, the big engines boomed out in chorus, and with the prettiest possible spiral the Caproni turned and circled twice about the Statue of Liberty at a height of 2000 feet.

*By E. D. Sullivan in *N. Y. Herald*

AIRPLANE BOMBING*

NIGHT bombing is largely dependent upon atmospheric conditions. Certain objectives furthermore are difficult to see on nights which, though fairly dark, yet permit flying. On the other hand, at night anti-aircraft fire is much less intense. Consequently the night bombing machines need not be particularly adapted for combat work, and may concentrate upon carrying capacity. Each team operates individually and may make one or several trips over the objective in order to obtain a good shot, which, together with the possibility of flying at a comparatively low altitude, assures great accuracy.



HANDLEY-PAGE BOMBER IN FLIGHT (ENGLISH)

The incubus of a heavy load of bombs so reduces the climbing and flying speeds of the day bombing planes that they are liable at all times to be overtaken and attacked by enemy scouts. Surprise raids can succeed only against objectives at short distances when numerous planes are employed, or at long distances by isolated machines. The latter plan is not resorted to save in exceptional cases. It follows that the day bombing plane has the following characteristics:

A powerful defensive armament, the highest circling and greatest speed compatible with the charge of bombs and gasoline to be carried, strength, and maneuvring ability for bombing at low altitudes. The squadrons are above all else used in formation flying and defensive combat. The necessary conditions of their employment reduce their loads and the accuracy of their results. On the other hand, day bombing continues the attacks of the night squadrons, secures photographs of the objectives in the course of its raids, brings down enemy planes, disperses the efforts of the enemy's pursuit aviation and takes part in the actual fighting on the field of battle. It may be used either on the immediate battlefront in intimate relation with the pursuit branch, or a part of it may be employed to hamper the enemy's scout service by raiding sectors far from the front.

Night bombing offers more opportunity for the employment of mature judgment and scientific method than any other branch of the service. Visibility at night is extremely variable, depending upon the clearness of the atmosphere, absence of fog and the light given by the moon. Natural landmarks fall into the following order, according to the ease with which they can be seen: Woods, important towns, roads, watercourses, canals, lakes and swamps. It is not difficult to see on dark nights even if they are slightly foggy, but visibility is limited to points immediately beneath the machine, and hence points of direction cannot be used to navigate by, but the itinerary must be laboriously picked out step by

*Notes by U. S. Instructor in Bombing (*N. Y. Times*)

step. On foggy nights, when the sky is completely covered with clouds, visibility is so limited that it is difficult to navigate save by lighted landmarks or to bomb other than illuminated objectives.

At all times these lighted landmarks are the greatest of all aids to the night bombers. Within our own and the enemy's lines, despite all precautions, there is always a certain amount of natural illumination, the lights of camps, of railroads, of towns and of factories in action. The groups of searchlights placed around important objectives, and generally thrown into the sky as soon as an enemy machine passes the lines, are visible from a great distance and serve as guides. The rockets from the trenches on dark nights, and the flashes of artillery in active sectors may help to refind our lines, and finally the system of flares and searchlights within our own lines, defining the aerial night routes, supplies the bombers with points of reckoning upon which to take the course of their objective and return to their aerodrome. Also, when the enemy's night service is in action its corresponding system of lights, which is fairly permanent, is of invaluable assistance.

Navigation is accomplished by means of maps, compasses and when possible the stars. As their experience increases, however, teams constantly strive to reduce their dependence upon such aids by familiarity with the sector in which they are operating. Nevertheless the use of maps remains indispensable, particularly for distant raids.

Formation flying is almost impossible at night. The machines take the air generally three to five minutes apart.

The summits of the highest mountains do not give an impression of solitude equal to that experienced by those who fly at night. On crossing the lines and at the noise of the raider's engines all the enemy's lights for a radius of fifteen miles or more are extinguished. The sharp rattle of a machine gun and the cough of the anti-aircraft gun announce that the enemy is getting into action. Bullets whistle, shells burst and the enemy's searchlights put forth their long fingers.

When the objective is small and well defended, the aviator withdraws, returns, withdraws again, and waits for his chance. If the barrage is concentrated at certain points of its circumference, the machine side-steps them and returns upon the target from another quarter. Though the circle of defense be complete, the barrage cannot nevertheless occupy all altitudes. If the shrapnel is bursting between six or eight thousand feet the bomber climbs to nine thousand or descends to five thousand.

There are among the night fliers some aviators mounted upon rapid high-powered machines, whose business it is to destroy certain precise and difficult objectives, such as convoys, columns of troops upon the march and moving trains.

Flying in formation makes it possible to penetrate to a great distance inside the enemy's lines and to repulse attacks successfully without abandoning the mission. The ideal formation must be simple in form, usually in the shape of a closed V, should leave no dead angle of possible attack which cannot be reached by the fire of two or more of the guns, should concentrate its firing possibilities in the rear, admit of a rapid closing up on the leader, and permit each plane to see as much of the other planes in the group as possible. Formations of more than eight planes are rarely used. They are too difficult to lead well, and greatly reduce the horizontal and climbing speed of the group as a whole.

The group is under the orders of the flight leader, who invariably flies in the leading machine. He may be either pilot or bomber. The secondary flight leader, who replaces the leader if the latter is obliged to fall out or is brought down, may occupy any position in the group. In passing over the objective, as well as during an attack by enemy machines, the formation is held as tightly as possible. The lateral errors which result from bombing in formation are, in view of the average dimensions of daytime objectives and the dispersion of fire desired, entirely admissible. The problem of the direction of the shooting lies of course in the care of the bomber in the leading machine, while that of range may be settled also by a signal from him or may be left to each individual bomber. Present bombing sights render a fair precision possible even in the most difficult circumstances.

When several groups take the air at the same time, they generally follow in sight of one another at intervals of a mile or less, in order to be of mutual aid in case of attack. They frequently execute a combined operation, converging upon the same objective, or attacking neighboring points at the same time. If, on the other hand, the groups do not leave together, an interval of at least two hours is allowed to elapse between them in order that the enemy's pursuit planes which have taken the air against the first flight shall have returned to the ground before the second flight passes over.

BREGUET BOMBER (FRENCH)

NAVY DEPARTMENT AIRPLANE SPECIFICATIONS

THE general specifications of requirements issued by the Navy Department for use in connection with contracts, and the submission to it of new and undemonstrated designs of airplanes, are interesting as indicating broadly the state of the art from the standpoint of this arm of the Government. The specifications are comprehensive, and give clear evidence of ability and knowledge having been applied in the preparation of them.

Although the requirements which are summarized below in large part, may be modified in the case of completed airplanes available for demonstration, sufficient information is essential in any event to permit reasonable verification of claims of performance and as to strength.

No new project will be encouraged unless it promises a marked advance over planes in service or already under trial. Great consideration will be given to possibilities for immediate manufacture, facility of upkeep and rapid dismounting of engines, and reduction of general dimensions.

General arrangement plans, one-twelfth or one-twenty-fourth full size, showing plan, side and front elevations, are to be transmitted. The following are to be indicated:

Over-all dimensions, and principal dimensions of portions shipped partly assembled;

Gap, chord and stagger;

Positions and angles relative to the propeller axis for the main and auxiliary surfaces and floats;

Position of center of gravity of airplane for full load and light load as defined under Rules Governing Conduct of Trials;

Position of center of buoyancy and corresponding water line of the float system when at rest on the water with full load;

Position of axis of landing wheels relative to center of gravity for full load;

Clearance of the propeller: For tractor types to be shown with the propeller axis horizontal; for pusher types to be shown with the airplane in position at rest on the surface;

Angle of attack at rest on the surface under full load;

Areas of main and auxiliary surfaces;

Dihedral angle; sweep back; wash-out or permanent warp, if any.

The detail plans called for are:

Details of spars, showing full size of the spar section in each bay;

Section of aerofoil, showing with dimensions the positions of the spars and details of wing ribs;

Details of wing struts and drift struts, showing full size the central cross-sections, and details of taper, if any;

Details of typical strut terminal fitting and wing spar fitting, with anchorage to wing spar and to stagger, lift and landing wires;

Details of hinge connection between wing panels;

Details of aileron, elevator and rudder hinges and horns, and general construction plans of these surfaces;

Details of float construction, including lines and a statement of reserve buoyancy.

The required assembly plans are those showing:

The arrangement of all control leads and types of fittings used with them;

The installation of compass, instruments, armament or other special gear.

Arrangement of wing wiring, including lift and landing wires, drift and stagger wires, and tabulated strengths;

Landing gear and shock absorbers, size of wheels, tires, axles and struts;

Propeller proposed, including section and angles at stations 0.15, 0.30, 0.45, 0.60 and 0.90 of radius;

Mounting and general installation of the engines, with oil and gas tanks, starting, air intake, exhaust, and all piping arrangement;

Cowling and ventilation arrangements for engine and cooling system, giving complete specifications of radiators employed.

These further data are asked for:

Detailed tabulation of estimated weights, showing weights included in light load and full load with the calculation of the location of the center of gravity vertically and horizontally for each of these conditions with reference to the front edge of the lower plane with the propeller axis horizontal;

Diagram showing loads on the principal members of the wing and body truss, including a tabulation of the characteristics of the principal members, their loads and stresses under the several conditions specified under Factors of Safety;

Calculated performance chart, showing the curve of effective horsepower required, the propeller efficiency, and the effective horsepower available, all based on velocity of advance in miles per hour; also a curve for the engine employed, showing brake horsepower plotted against revolutions per minute;

A statement of the type and principal characteristics of the engine proposed, together with oil and fuel consumption per brake horsepower hour;

A statement of the performance with full load at sea level including: Weight, full load; useful load; maximum speed; load in pounds per square foot of plane area, including ailerons; load in pounds per horsepower; climb in 10 minutes; tank capacities for fuel and oil; endurance at full power at sea level.

The airplane must have construction permitting facility of observation, inherent stability, ease of control and comfortable installation for the crew.

The general specifications are to be construed to include Bureau of Construction and Repair and Bureau of Steam Engineering detail specifications in effect at the respective date. All materials and processes are to be in accordance with any such detail specifications; otherwise, in accordance with trade custom as approved by the inspector.

It is stipulated the contractor shall provide all material, parts, articles, facilities, plans and data to conduct all trials. Non-metallic materials, such as dope, glue, varnish and plywood, are supplied by firms on the approved list of the Bureau of Construction and Repair.

Inspectors may reject peremptorily any inferior workmanship or material. The contractor has the right of appeal to the Department, whose decision is final.

The contractor is obligated to furnish under the contract, without additional cost, such samples of material and information as to the quality thereof and manner of using same as may be required, together with any assistance necessary in testing or handling materials for the purpose of inspection or test. The passing as satisfactory of any particular part or piece of material by the inspector will not be held to relieve the contractor from any responsibility regarding faulty workmanship or material which may be subsequently discovered.

As soon as work on the contract is started the contractor is on request to prepare for approval a full-size model of the cockpits, showing the general arrangement and disposition of seats, safety belts, controls, instruments and accessories located therein. The object of this is to test the feel of the cockpit for roominess, convenience of control, suitability of location of all parts and amount of view afforded.

Engines, armament, instruments and accessories will be supplied by the contractor or by the Department, and be installed by the contractor in an approved manner and location.

The engines, armament, instruments or other fittings, to be supplied to the contractor by the Department will be free of cost, but the contractor will be required to fit them in the machines at his own risk and expense, and be solely responsible for carrying out successfully the requirements of the specification.

Alterations and substitutions will be permitted only upon the approval of the inspector in charge, but wherever such alterations may affect the contract plans and specifications,

the aerodynamic qualities, structural integrity, or military characteristics, such approval must be obtained from the Department through the inspector in charge.

All changes approved by the bureaus or requested by them will in general be of two classes: First, those of immediate military importance or necessary for safety, which will be incorporated in all units at once, and new parts shipped after units already delivered, so that the stations may incorporate the changes; and, second, changes which are desirable but not so urgent as to warrent interference with production.

In case of the first three machines of a new type, all material of every description placed on or attached to the airplane is to be weighed, together with all material of every description which, after being weighed and placed on or attached to the airplane, is removed; and such weight and description of the part weighed in all cases reported to the inspector.

Where material is assembled before being weighed, the center of gravity of such assembly is to be ascertained. The center of gravity of each part or group of parts entering into or attached to the airplane must be reported in relation to the front edge of the lower plane with propeller axis horizontal.

Parts which are partially or completely assembled before installation are photographed and prints supplied. In addition photographs of the complete assembly are to be submitted, giving the maximum amount of detail in not less than four positions.

Plans and Data

One set of general arrangement plans shall accompany each airplane for use in erection, together with a set of instructions for erection; also construction specifications of the airplane; specifications and statement of sources of supply of all wood, veneers, metals, forgings, stampings, wire, cable, glue, fabric, dope, paint, varnish, tubing, pulleys, tanks, etc.; description of practice followed in seasoning wood and heat-treating metal, finishing fabric, securing fabric, making wire and cable terminals, rustproofing of steel parts, waterproofing of wood parts; and statement of the parts that have been brazed, welded or soldered.

Landing Gear

The landing gear must be of an approved design and construction. Location of the wheels shall be such as to prevent any undue "spinning" when landing down wind under conditions specified. Particular attention will be given to simplicity of design, reduction of head resistance, and the least weight consistent with the service intended.

Staunchness of construction is required while disposing material to greatest advantage, transmitting loads by suitable fittings and fastenings into the principal members and through them to the structure as a whole, in order to obtain strength without excessive weight. If at the same time resilience can be obtained it will be an advantage, and shock absorbers may be employed if their introduction involves improvement in performance. Streamline form is desirable but must not be permitted to affect seaworthiness.

Water-tight subdivision is required as well as suitable access and drainage for each compartment. Hulls having double bottoms to the step, are to have suitable draining arrangements incorporated in this false work. Drain-plugs and handhole plates are required on tail and wing-tip floats as well as on main floats. Flying boat hulls are provided with a hand bilge-pump and means for pumping out any compartment when the craft is adrift at sea. Double skin boats shall have cotton sheeting and marine glue between the plys. Bulkheads should be utilized as strength members and be reasonably water-tight for at least twelve hours.

The form of the bottom should be such as to permit easy planing with longitudinal control. The form should also be such as to reduce the shock of landing or of running at high speed on rough water. The stability when afloat in a moderate sea with any one compartment of any float completely or partially flooded, should be such that the seaplane will not roll or tip over. Provision is required against bursting due to the change in pressure involved in ascending to the maximum altitude contemplated in the design, and the first float of a new type may be subjected to an internal pressure corresponding to this altitude. Suitable skids, keels, edge strips, footholds, walking strips, etc., are required to prevent undue chafe and wear in service. Towing cleats and nose rings shall be of approved design and location.

All internal metal fittings and all fastenings shall be copper or brass, and all external metal parts shall be adequately protected against the action of salt water.

Holes for fastenings are to be carefully bored and care taken to avoid splitting the wood. Rivets and clinched boat nails are to be used in preference to screws wherever possible. Dead nails are not to be used. Glue should not be relied upon as a jointing material in any boat or float work. Any splices in strength members must be secured by copper rivets and if possible by whipping in addition. The type of splice shall in any case be submitted for approval. Any propeller which has not a float directly beneath it is to be so situated that clearance between the propeller tips and the water is not less than two ft. when the seaplane is afloat at rest, or is afloat at rest with the tail lifted to the flying attitude. Propeller clearance immediately over floats should be at least two in.

Body

The form and disposition of body members and fittings are such as to provide positive alignment and minimum distortion under the loads to be met in service. For seaplanes, the crew must be able to get out quickly in case of accident. Suitable footholds are to be provided to enable the crew to pass to the main floats and to the engines to make minor adjustments while the machine is afloat.

Longitudinals may be spliced only in approved manner. Longitudinal fittings shall be properly anchored to take shear, but through-bolts should be used with caution. All wires used for trussing are to be solid except where readily accessible, or where the use of other types is approved. A suitable windshield is to be fitted to each cockpit. For each seat an approved safety belt will be supplied. Removable seat cushions are to be so attached that they cannot shift when in flight.

Engine Installation

For seaplanes the engines shall be capable of being started by the crew when the machine is afloat in a seaway. The engines shall be accessible and easily removed and replaced as a unit with a minimum disturbance of fittings.

Engines are to be effectively cowled with sheet metal, with parts easily removable for access. Cowls for rotary engines shall protect crew, planes and body from oil and smoke. The exhaust is not to interfere with the crew, nor is there to be any danger of fire due to it. Effective mufflers are to be provided unless specifically excepted. Approved provision is to be made for the entrance and exit of air for the purpose of cooling the engine base and cylinder heads. In tractor airplanes a flame-tight metal bulkhead immediately behind the engine is provided. Means are installed in the pilot's cockpit for extinguishing fire forward of the fire bulkhead. The body beneath the engine has a metal cover sloping to the rear with an opening at the rear edge extending the entire width. The bottom of the body behind this point is to be covered with metal for at least three feet. Suitable drip-pans and drainpipes leading clear of the body are to be provided to get rid of gasoline overflowing from the carbureters or elsewhere. Carbureter-float covers shall be so secured as to prevent leakage of gasoline. Careful consideration should be given to conditions surrounding air supply to the carbureter to insure that spray and rain are not drawn in and that freezing does not occur in the carbureter or induction pipes at high altitudes.

A head of at least 5 in. shall remain above the outlet to each cylinder when the reserve water allowed has been boiled away or otherwise lost, and with the machine inclined upward 25 deg. to horizontal, or 10 deg. list to either side. Radiators shall be tested filled with air at 8 lb. per sq. in. pressure when totally immersed in water.

Foundations

All foundations for engines, radiators, seats, control gear, guns, bomb storage, releasing gear, etc., are to be thoroughly supported from panel points.

Fuel Tanks, Piping, Etc.

Fuel tank location is nearly central. Gravity feed to the carbureter, under normal conditions of flight, or a service tank having at least a half-hour capacity, is provided. Each tank has independent leads either to the service tank or carbureter. If gravity feed cannot be obtained, proper and approved means in addition to a hand-pump, are provided for supplying the service tank. Efficient strainers are required in each fuel-tank lead. All solid piping shall be annealed after bending. All joints shall be brazed.

Fuel tanks shall be tested with an air pressure to give

three pounds per square inch at the carbureter without showing leaks or unreasonable deformation. Swash-plate bulkheads should be fitted and the heads so formed as to prevent vibration. If gravity feed is used, the tank shall be fitted with a suitable vent, which will close and prevent leakage of gasoline through the vent in case the airplane turns upside down. Tanks shall be non-corrosive and made of annealed material where possible. Filling-caps are to be secured with chain lanyards.

All gasoline, oil and air-pipe joints are to be electro-conductive, and where the joint has to be made with an insulator, such as rubber tubing, it must be short-circuited by an approved method. The gasoline and oil supply are to be so arranged that the delivery of gasoline and oil will continue under the normal air pressure (if so fitted) until the tanks are empty, in any reasonable position of the machine. The ignition and auxiliary circuits must be thoroughly protected from short-circuits by spray. A positive means of quickly cutting off the gas at the service tank shall be readily accessible from either seat. The fuel leads, the control leads, and the carbureter adjusting-rod shall be provided with suitable, safe and ready couplings where those connections have to be frequently broken. The oil thermometer bulb shall be installed in the oil-sump or other approved location where it shall be covered with oil at all times. The circulating-water thermometer bulb shall be installed in the outlet pipe of the engine near the radiator, or in other approved location.

Controls

Plans showing the general control system shall be approved before installation. All control gear and control cable shall be readily accessible for inspection and lubrication. The control surfaces and actuating mechanism shall be so arranged that under no circumstances shall they jam or foul, and the whole system shall have an approved margin of strength and rigidity.

All control gear shall be so placed that it will be protected from sand and dirt. Control wire shall be kept up away from floors.

All control operating horns shall be relieved of bending stress by at least one wire unless otherwise approved, and control columns, posts, bars and pedals shall be proportioned to prevent bending in service.

Welding of control horns is prohibited except for longitudinal seams.

All control leads shall be of stranded cable of an approved flexible type and make, and shall be thoroughly stretched before fitting. Where the control lead passes around a pulley or drum, the wire shall be guarded against coming off. Such guard will not be approved if the cable can be forced off its pulley or drum when quite slack, by pushing the two ends of the cable inwards with the hands. All control pulleys shall have ball bearings. The radius of curvature of pulleys or fair leads for control wires shall be not less than fifteen diameters of the wire for a 90 deg. bend. The turnbuckles in control wires shall be in approved positions as far as possible from the compass, and accessible for adjustment.

The handwheel, if employed, shall be made exclusively of non-magnetic material with the inner edge of the rim corrugated. The rim shall be fastened in a secure manner and the use of wood screws for this purpose will not be allowed.

Each elevator half is to be provided with one pair of operating horns (or their equivalent), each with independent leads.

The steering is to be by means of foot bar or pedals, adjustable fore and aft for at least six inches. Arrangements are to be made to prevent the pilot's foot slipping off the foot bar or pedal. If a foot bar is used, guides are to be fitted to prevent vertical play; also stops sufficiently high and strong to prevent the bar bending or overriding them.

The controls need not be non-magnetic for the trials, but if the compass is affected, replacement with non-magnetic gear is to be made. The fixed control fittings should preferably be non-magnetic, but permission may be given to use magnetic fittings if it is considered that there will be an advantage in weight, strength or convenience of manufacture.

If, on the engines employed the throttle and magneto advance levers are interconnected and brought to a single lever, this lever shall be operated by a separate hand-lever for each engine. When the throttle and magneto are not interconnected, a separate hand-lever shall be provided for each engine, these systems being so arranged that the pilot can control with one hand the engines individually or together. The hand-levers to the throttle and ignition and to the engine switches, in case of machines carrying two or more pilots, shall be arranged by duplication and interconnection of levers, so that either pilot can operate them when in flight. The forward position is to be the position for full power. Each throttle or magneto advance lever is to be fitted with an approved system of positive location. A spring, capable of opening the throttle in the event of the control gear breaking, is to be fitted at the engine end of the throttle-control system. The engine switches are to be of an approved type and so placed for each engine that all can be moved simultaneously with one hand, the direction of motion for shorting to be approved. Ground wires for switches are to be led direct to the engine and not to the engine mounting.

Wings

Spruce or Port Orford cedar for wing spars shall be selected from the clearest, finest stock available, shall have a density in excess of 0.36 and 0.42, respectively, based on oven-dry weight and volume, and, if possible, more than eight rings per inch.

The spar shall be suitably increased in dimensions where it is pierced by bolts. Particular attention is to be given to this point when the spar is pierced by bolts not approximately on the neutral axis. The fitting and its method of attachment to the spar shall be so designed that the failure of any part of it shall not cause the struts to be displaced or both the flying and stagger wires to be released.

Either brass or galvanized-iron brads shall be used to fasten cap strips to ribs; but brass screws shall be used to fasten cap strips to spars.

In order to prevent relatively weak portions of the machine from damage in handling, hand-grips shall be fitted in suitable positions near the extremities of the lower planes.

Control Surfaces

All ailerons shall be double-acting. For large machines in which control by means of unbalanced surfaces will be obtained with difficulty, balanced surfaces of approved form shall be provided.

The horizontal fixed tail surface shall be so designed as to permit of adjustment in angle. Arrangements may in some cases be made for this adjustment while in flight.

Elevators shall be on same axis tube or locked together in such a manner that the control is not rendered useless if one set of control wires breaks.

Wing Struts

Wooden wing struts, if hollow, shall be taped, doped and varnished. Any strut even slightly warped will be rejected. Wooden struts shall be made of clear straight spruce, Port Orford cedar or white pine of finest grade, close-grained and well seasoned. For struts the inspector will select spruce or white pine having a density in excess of 0.36 or Port Orford cedar having a density in excess of 0.42 and, if possible, more than eight rings per inch.

Propellers

The propeller hub faceplates shall be interconnected, independently of the propeller bolts, so that each plate is used to drive the propeller. Wood propellers shall be fitted with sheathing which shall extend a distance from the tip of the blade toward the center approximately one-fourth the diameter on the leading edge and eight inches on the trailing edge, as a minimum; detailed requirements may be found in Bureau of Steam Engineering, Instructions for Tipping Seaplane Propellers. Non-corrosive rivets or screws shall be used.

Factors of Safety

The factors of safety specified apply in general to all airplanes. In all cases the burden of proof rests upon the contractor to demonstrate by submission of his calculations in detail that the airplane is structurally safe. Any part or parts whose strength is in doubt shall be tested by sand loading or other approved method. This specification refers in particular only to the most important structural members. For foundations, terminals, fittings, braces and minor structural parts, for which calculations are indeterminate or loading unknown, good engineering practice shall be followed.

The wing truss consists of the wing spars, interior bracing, struts and exterior bracing together with all wire or cable anchorages, but does not include non-strength parts, such as leading and trailing edge strips, ordinary ribs, tape, cloth, battens, corner blocks and fairing pieces. It is assumed

that the wing truss carries in normal flight the full weight of the airplane and, in addition, the drift of the wings, struts, external wires and any appendages, such as skid fins, wing floats, etc.

In biplanes the distribution of loading on the wings shall be computed by the formula:

$$W = A^u x \frac{11}{9} + Ax, \quad (1)$$

in which W = total lift load, A^u = area of upper wing, A = area of lower wing, and x = unit load on the lower wing, which is obtained by solving the above equation.

In triplanes the distribution of loading shall be computed by the formula:

$$W = A^u x \frac{5}{4} + A^m x \frac{3}{4} + Ax, \quad (2)$$

in which A^m = area of middle wing, and other notation is the same as in (1).

The stresses imposed in the wing truss are figured from the net lift which equals the total lift less the weight of the wings and the interplane bracing.

Ailerons are considered as wing area, but in special cases, when ailerons are of unusual design or size, or operated by servo-motor, the Department may require a special investigation of wing truss strength as affected by aileron loads.

The total lift load on each wing is the product of the area of that wing by its unit load and is assumed to be applied uniformly along the spars and distributed between them in inverse proportion to their chord distances from the assumed center of pressure. At high speed the center of pressure shall be assumed at 0.5 of the chord distance from the leading edge, except when reliable wind tunnel data on the center of pressure travel and monoplane lift coefficients for the aerofoil employed are available, in which case the center of pressure for high speed may be calculated from the wing loading at high speed by obtaining the flying angle from the monoplane lift characteristic. At low speed the center of pressure shall be taken at 0.28 of the chord distance from the leading edge, unless an unusual aerofoil is employed, in which case the center of pressure travel may be modified if data from wind tunnel tests are available.

Besides the lift load defined above, the wings carry a drift load which may be assumed equal to one-quarter the lift load and applied at the center of pressure. This drift is assumed to include the drift of wings, struts, wires and appendages. Where data from wind tunnel tests are quoted, the fraction of lift applied horizontally as drift may be altered. This drift load may then be divided between the spars and distributed uniformly along them.

Resolve the running lift and drift loads for each spar into a single running load in the plane of the principal axis of the spar and, making use of the Theorem of Three Moments, compute the bending moments in the spar and the reactions at the joints or points of support.

Assume, as a first approximation, pin joints with all loads concentrated on joints and compute direct stress in each member after having resolved the loads into the planes of each group of members—i. e., plane of front struts, plane of chord of top wing, etc. For spars, combine the direct stresses due to lift and to drift with the stress due to bending.

The *horizontal shear* in the wing spars should be computed for sections near the strut ends where the spar has its usual section.

Directly over the struts the wing spars shall not be hollowed out, and if pierced by bolt-holes allowance shall be made in all computations for the sectional area of the holes. Wood spars of I-section shall have the web at least equal in thickness to the flanges and cut with generous fillets.

All splices in solid wing spars shall be located at points of contraflexure or minimum bending moment. When the exact location of these points is not known, they may be assumed to occur at from one-fourth to one-third the distance between consecutive interplane struts.

Splicing of unlaminated spars or of laminations of laminated spars will be permitted provided the type of splice is approved by the Department.

In splicing solid wood spars of I-section the spliced section shall not be routed out.

Fittings for pin-joints at butts of wing spars are to be designed so that securing bolts cannot crush or shear through wood under loads specified below.

Struts shall be computed as if made with pinned ends whether or not the ends are actually pinned.

For *wires and cables* allowance should be made for the efficiency of the terminal. Similarly, the strength of the fitting to which the wire or cable terminal is secured must be considered in the wing truss design. Wires and cables should be so led as to introduce no eccentric loading on structural members and anchored in fittings designed to develop their full strength.

The *stagger wires* are to be assumed to carry the drift of the top plane. Where the top plane passes over the body, the entire drift of the top plane is assumed to be carried into the body by the stagger wires and struts at that place as if acting alone.

Cross *transverse diagonal wires* over the body holding the top plane from racking as the airplane rolls should be computed to hold the rolling moment obtained by assuming an up load of 20 lb. per sq. ft. on one set of ailerons and an equal down load on the opposite set.

Wood

Air seasoning is preferred, but forced drying will be permitted if approved methods are used. Laminated wood shall not be used unless approved by the Department. Spiral grain will be allowed only as permitted in specifications issued by the Department for each type of machine in production, and in case of doubt test sticks shall be split. No spruce or white pine below 0.36 density, Port Orford cedar below 0.42 density, or ash below 0.56 density in oven-dry condition shall be used in important strength members. Wood splicing shall be only as approved. The splices shall be of efficient form and the grain shall not be turned. Bolts or rivets shall be used if required, and the joints shall be finally taped or served and glued as prescribed.

All dope, enamel, paint, varnish, shellac, waterproof, hide, or marine glue shall conform to Department specifications.

Metals

Where the material is of a class susceptible of improvement in quality by heat treatment, such treatment shall be given as a final step in manufacture, except in the case of small parts. In the latter case the heat treatment shall, if practicable, be given before fabrication or else the parts shall be made from heat-treated stock.

Steel shall not be left in finished parts in a hot-rolled, hot-forged, or cold-forged condition. Normalized steel must be renormalized after forging (hot or cold), welding, or otherwise heating.

Hard-drawn steel must not be heated.

Laminated fittings of metal which are brazed or welded shall, in addition, be thoroughly riveted. Welding and brazing shall be restricted to parts not otherwise possible of fabrication, and only in approved locations.

Acids will be used in soldering only where expressly permitted. If used, after soldering all acid shall be neutralized and washd out in an approved manner.

Wire

Solid wire shall be carefully formed to perfect eyes without any rebending, and the eyes shall be properly formed to prevent crawling. Eyes should be examined for signs of lamination and cleavage. Cable shall be tacked with solder before cutting or cut with acetylene flame to prevent uneven stress due to unlaying. At the time of tacking the wire shall lead straight.

Wire with hemp centers shall have the center locally removed before making up the terminals so that the center strand will carry no load. The ends of all cables, whether flexible or otherwise, shall be fitted with thimbles or other approved device to minimize slackening in service. Where cone cups are used for terminals the double mushroom may be required unless the workmanship is such as to show by test perfect terminals in every case. Taper plugs shall not be used. All wire terminals except those of the cone-cup type shall be soldered. Cone cups will be puddled with zinc and care taken to prevent drawing the temper of the wire.

Wherever wires are inaccessible for adjustment, as is the case inside the wings and auxiliary surfaces or in parts of the body or floats, solid wire shall be used unless otherwise approved.

Cable stays shall be made up complete with terminals and proof stretched before installation with a load equal to one-quarter of the ultimate tensile stress.

Fabric

Wing, body and auxiliary surfaces shall be covered with linen or cotton conforming to Aeronautical Specifications,

C & R Nos. 12 and 13, respectively. On the wings, the fabric shall be applied either diagonally or with seams running normal to entering edge. On the wings, the tape and lacing method shall be used, with loops spaced not more than four inches apart. The thread shall be knotted at each loop or made fast with a double half-hitch, and then cemented with dope. The tape used in wing construction shall be of the same quality of fabric as used for the wings. Tape used on laminated struts or built-up parts shall be applied with glue and then doped. Thread used for stitching seams shall be of an approved linen or silk and shall be waxed.

Pontoons Fabrics

In built-up laminated floats, bottom planking and bulkheads shall include cotton sheeting applied with an approved grade of marine glue between laminations.

Requirements of Finishing Materials

Acetate and nitrate dopes used on all work shall be in accordance with Aeronautical Specifications, C & R Nos. 1 and 2, respectively. Spar varnish and naval gray enamel used on all work shall be in accordance with Aeronautical Specifications, C & R Nos. 3 and 4A, respectively.

Doping

The doping of all naval planes, with the exception of H-16 and F-5, shall conform to the Navy Standard Doping System A.

Navy Standard Doping System A

Wings, control surfaces and fuselage fabric—On all fabric two coats of cellulose acetate shall be applied. This treatment shall be followed by the application of a sufficient number of coats of cellulose nitrate dope—not less than two or more than four coats—to obtain satisfactory tautness and finish. After the last coat has dried for not less than twelve hours, naval gray enamel shall be applied; two coats on vertical surface, two coats on top sides and one coat on the under side of horizontal surfaces.

On H-16 and F-5 planes, acetate dope shall conform to Navy Doping System B.

Navy Doping System B

Wings, control surfaces and fuselage fabric—On all fabric five successive coats of cellulose acetate dope shall be applied. After the last coat has been dried for not less than twelve hours, naval gray enamel shall be applied; two coats on vertical surface, two coats on top sides, and one coat on the under side of horizontal surfaces.

Finish for Metal Parts

Plating—Zinc coating is preferred and should be used wherever practicable. When galvanizing is employed, the zinc coating should conform to Aeronautical Specifications, C & R No. 39. Special alloys and heat-treated steels may be affected if galvanized by the hot-dip or other processes employing high temperatures—375 to 450 deg. C. On such parts, as well as on accurately dimensioned small parts, the electro-galvanizing process (zinc plating) should be given preference.

Cleaning—Sand blasting is preferred for cleaning metal previous to plating. Pickling of metal surfaces with acid should be avoided wherever possible, since pickling increases the brittleness of metal and has a very unfavorable effect on thin stock. Pickling should especially be avoided on metals that may be subjected to continual vibration. Wherever pickling is used, the metal should be thoroughly cleaned with water so as to remove the pickling acid previous to plating or finishing. Threaded and brazed parts are often cleaned satisfactorily in tumbling barrels with oil and emery.

Painting—After plating or coating with zinc, copper or nickel, metal fittings shall be finished with enamel, Specifications C & R No. 4A gray or No. 5 black. After assembly all metal parts that show bare places shall be touched up with enamel. Interior plated or zinc-covered fittings such as tubes or aileron horns and all such parts having cavities shall be dipped in enamel and then allowed to drain and dry. This process is included to insure interior protection against corrosion. Steel tubes having sockets or caps on the end may be drilled with two holes. Thinned enamel may be poured in one hole and allowed to drain. After the enamel is dry the holes should be plugged.

Wires and Cables

All fixed external wires or cables shall be carefully cleaned and coated with spar varnish containing 5 per cent of Chinese blue.

All fixed internal hull wires or cables and all internal wing wires or cables shall be painted with naval gray enamel.

All control wires or cables shall be heavily coated with an approved grease.

Rules Governing Conduct of Trials

Light load—Comprises the airplane complete in order for flight, including water in radiators, water and oil thermometers, tachometer, dashboard instruments, starters, all tanks and gages and armor, but without those items included in "Useful load."

Full load—Comprises the airplane complete as specified under "Light load" and in addition the "Useful load."

Useful load—Comprises fuel and oil, crew, armament, equipment and accessories as detailed in the contract.

At the beginning of each trial of any performance, the airplane shall be brought to the prescribed "Full load" condition.

The first successful trial under the conditions prescribed shall be final, and no further attempts shall be made.

Throughout the trials the powerplant (including propeller) and the airplane shall be identical in every respect with that which it is proposed to deliver for service.

The gasoline used shall be of a commercial grade readily procurable.

Demonstration trials include the following, in which the airplane shall meet the performance requirements of the contract:

(*a*) High speed, (*b*) Climbing, (*c*) Maneuvering on the surface and (*d*) Maneuvering in the air.

Immediately after each trial an inspection of the airplane and powerplant shall be made to determine that all parts are in good condition and functioning properly.

Not more than four official attempts will be allowed in which to make either the high speed or climb prescribed.

The manner of conducting the high speed and climbing trials shall be as agreed upon.

Maneuvering on the Surface

Landing—The airplane shall be capable of being landed down wind with dead motor under prescribed conditions. Such landing shall be made with no tendency of the airplane to spin dangerously or to turn over on its nose.

If required, the airplane shall be driven along the ground in a straight line in any direction with respect to a wind of a velocity between 15 and 20 m.p.h.

Maneuvering on Water

Seaworthiness will be demonstrated by maneuvering on the surface at anchor, adrift and under way.

The purpose of such trials is to determine staunchness, stability, planing power and longitudinal and directional control under varied conditions of the wind and sea, representative of conditions to be met by the type under consideration.

In a calm, with full load, the seaplane shall steer readily. At all speeds up to "get away" the seaplane shall respond readily to the controls. It shall "plane" at moderate speed, accelerate rapidly, and get away within the distance specified. It shall show no uncontrollable "porpoising" or tendency to nose over at any speed. Under this condition the propeller should be free from spray and broken water.

In a moderately rough sea the seaplane shall steer readily in all directions and at all speeds. It shall "plane" at moderate speed and without undue "porpoising" or tendency to nose over under any condition with the wind forward of the beam.

With the wind abaft the beam it should be capable of running slowly or at moderate speed without nosing or without undue spray or broken water entering the propeller disk. Down wind at wind speed there should be sufficient reserve of stability to prevent nosing over.

Headed into the wind there should be no marked tendency to yaw.

In a rough sea the seaplane shall steer readily in all directions at moderate speed, and shall steer readily at any speed with no tendency to yaw with the wind anywhere forward of either beam. It should be able to get off and to land headed approximately into the wind without undue punishment to the seaplane or propellers.

Adrift or riding to a sea anchor or to a ground anchor the seaplane should not take any dangerous attitude in a calm, moderately rough sea, or in a rough sea.

Current Standardization Program

IMPORTANT rapid developments in some of the automotive industries, and the extended program, particularly of the Government, in practically all these, call for a carefully planned program for the establishment of important routine engineering standards in these industries.

Aeronautics

In the field of aeronautics a number of important and valuable standards have already been adopted and reduced to practice. Many important subjects remain to be acted upon. Brief mention is given some of these below.

Bolts with Nut Heads

This subject has already received considerable attention, but a few of the important details remain to be worked out. At the present time a series of tests is in preparation to determine the strength of built-up bolts as compared with regular machine bolts, and it is expected that a definite standard can be proposed at the January meeting of the Society.

Turnbuckle Fittings

Turnbuckle fittings, such as clips, shackles and pins, are still to be worked out in connection with the turnbuckle specifications which were adopted as recommended practice by the Society recently. The same general design, approved last year, will probably be followed, with the exception of detail dimensions which must conform to the latest turnbuckle dimensions.

Steels

Special steels for use in airplane construction are among the important subjects to be considered. Specifications should be established covering sheet steel, bars, screw stock, tubing and special forms.

Streamline Wire

Specifications have already been established for solid round and different flexible steel cables for airplane stays and other construction, but streamline wire and wire-ends have become important subjects for standardization. Work in this connection may include development of use of round wire with a rubber or light wood protective shield made up in streamline form.

Wire Bend-Test

With reference to the round high-strength steel wire specification, comparative tests between the hand bend-test and the machine bend-test were carried out recently by the Navy Department in Washington. The present specifications will probably be revised soon to include definition of method of test and a description of the equipment to be used.

Lock Washers

It is felt by some that the S. A. E. standard lock washers are not adequate to cover present aeronautic requirements. This matter will be given careful consideration.

Loops and Splices for Flexible Cable

The present specification should be more completely dimensioned in regard to the length of the tapering-off of the splice and the length of the serving.

Nomenclature

Aeronautic nomenclature is one of the important subjects before the Nomenclature Division of the Standards Committee. The report of the Royal Aeronautic Society on this subject is now being considered.

Division Activities

Ball and Roller Bearings

Sub-committees of the Ball and Roller Bearings Division have been at work preparing specifications on the following subjects:

Extra large and extra small annular ball bearings, magneto type ball bearings and annular thrust ball bearings. Practically all of the roller bearing industry is represented on a sub-committee organized for the purpose of revising the S. A. E. roller bearing specifications to take the form of a single specification providing a definite series of sizes of roller bearings and complete interchangeability between the straight roller bearing type and the taper roller bearing type, and also interchangeability of these with ball bearings so far as feasible. A session on this general subject was held in Cleveland on Oct. 23.

The subject of metric size thrust ball bearings was worked out to a proposal last year, but on account of the lack of definite information regarding the then established practice, it was decided to leave the subject in abeyance. The Division expects, however, to prepare a final specification at any early date.

Chain Division

The most important subject before the Chain Division is roller chain lengths and sprocket tolerances. Consideration of these subjects will be continued in cooperation with the A. S. M. E. Chain Committee.

Data Sheet Division

The Data Sheet Division has the perpetual task of revising or eliminating obsolete Data Sheets from the Handbook, particularly from Volume II.

Electrical Equipment Division

A partial specification for bracket generator mountings was finished and adopted by the Society this year. The Sub-Division which had charge of this work is now completing the specification by determining dimensions for the mounting bracket and the bracket pad cast on the engine crankcase, and should have a report ready for the January meeting.

The subject of marine electrical equipment is one on which probably a good deal of work will have to be done. A representative of the Electrical Equipment Division has been appointed to confer with a representative of the Marine Division.

Two rather important subjects remain to be reported on by the Division, namely, sleeve-type generator mounting and sleeve-type starting motor mounting. Preliminary work has been done on these subjects.

Engine Division

The subject of engine support arms, or general engine mounting dimensions, is still before the Engine Division. Information gathered from the various manufacturers

has been summarized and sent to the Division so that it should be ready to make a report in January.

Magneto couplings, flexible-disk type, constitute an unfinished subject, although extensive data have been turned over to the Division. An early report on the matter should be forthcoming.

Iron and Steel Division

An unfinished subject before the Iron and Steel Division is the review of the A. S. T. M. Steel Screw Stock Specifications, with the idea of settling definitely the percentages of manganese and sulphur in this stock, and revising the S. A. E. present screw stock specification accordingly.

Aeronautic steel specifications for sheet, bar and tubing stock are to be considered in cooperation with the Aeronautic Division.

Lighting Division

The subject of headlamp illumination has been the most active one in this Division, with the result that New York State legislation has been enacted embodying the result of the work of this Division in cooperation with the Illuminating Engineering Society. Further progress in this work will be dependent upon the working out of the law, with the intent of including definite candle-power values in the S. A. E. headlamp illumination specification.

Bases and Sockets—Electric Bulbs

The present S. A. E. specification of plugs and sockets should be revised and brought up to date and correlated as closely as possible with British practice. The British Engineering Standards Association has already been communicated with.

Other subjects such as lens sizes, classification of nonglare devices, signal lighting, road lighting, and lamp bulbs (sizes and ratings), are before the Division but are not important enough at present to require active attention.

Marine Division

Boat Fittings

No definite subjects under this heading have been assigned, but it is intended to consider fittings, such as deck and house fittings, suitable for standardization.

Standardized Units for Motor Lifeboats

Some action was taken on this subject early in the year, but not much progress has been made. It seems that there are not many items susceptible of standardization in this connection, outside of those already under consideration, such as engine fittings, propeller-shaft couplings, propeller-mount, and general boat fittings.

Swing Port Lights

Dimensions for a series of sizes ranging in two-inch steps from 10 in. to 18 in. light opening diameter have been worked out by the Sub-Division on Portlights and will be ready for final recommendation at the January meeting.

Fixed Port Lights

Information has been gathered from the industries covering this subject and is ready for submission with a view to proposing a standard series.

Engine Foundations and Shaft Centers

Dimensions used by boat engine manufacturers are being analyzed by the Sub-Division, of which Mr. Joseph Van Blerck is chairman. A tentative specification subject to approval by the industry, and for submission to the Society at its January meeting, is expected.

Other subjects before the Marine Division are: Fuel tanks, water-pipe flanges and connections, exhaust-manifold connections, marine engine tests, marine engine testing forms, twin-carbureter flanges, engine control, marine storage batteries and coupling carrying capacity.

Miscellaneous Division

The important subjects before the Miscellaneous Division relate to thread tolerances, tap drill sizes, bolts with various heads, nuts for machine screws, finish of the present S. A. E. bolt and nut faces, steering-wheel hub dimensions and screw and bolt classifications. It is expected that a Miscellaneous Division meeting will be held at Worcester, Mass., following a meeting of the National Screw Thread Commission planned for the near future, at which the bolt and screw thread subjects can be considered.

Nomenclature Division

The subjects before this Division are aeronautic, marine, motorcycle, tractor and truck nomenclature. The subject of truck nomenclature should receive consideration as soon as possible in view of the important truck production and specifications work being done by the Government.

Springs Division

A meeting of the Springs Division was held at the Washington office of the Society on Oct. 21. The subjects considered were spring shackle bolts and nuts, width of spring brackets, length of spring seat, and a review of the present spring standards.

Stationary and Farm Engine Division

This is one of the youngest divisions of the Standards Committee. Various subjects have been assigned to it. Probably several of the National Gas Engine Association standards, promulgated by it before its technical work was transferred to the S. A. E., can be adopted. A sub-division is preparing recommendations on this subject. Other Sub-Divisions are at work on such new subjects as crankshaft diameters and pulley extensions, oval and round pipe flanges, cast iron carbureter flanges, portable truck engine mounting dimensions and a simplified series of stationary engine sizes.

Tire and Rim Division

A number of items are before this Division, including Airplane Landing Wheel specifications, sections and contours of solid and pneumatic tires, a simplified series of solid tire sizes, cast-steel wheel dimensions and wood felloe and spoke dimensions. One of the most important subjects is International Tire Standardization. This work will be carried on in as close cooperation as possible with foreign producers.

Tractor Division

This Division has a wonderful opportunity to create some valuable standards. The industry, although comparatively new, is growing very rapidly under the stimulus of present conditions, and close cooperation of the manufacturers with the S. A. E. Standards Committee

will produce very beneficial results. Aside from the standards already passed, the new work includes such subjects as spark-plug dimensions, driving- wheel dimensions, implement and drawbar connections, pipe lines and fittings, special bolts and nuts and bell housings for flywheels. A sub-division has about completed a recommendation on the last named subject.

Transmission Division

The subject of mounting tire pumps on the transmission is scheduled for the Transmission Division. There is a growing demand for this type of mounting. Further standardization of clutch dimensions, and work on gears and gear-shifting equipment also should be accomplished.

Truck Standards Division

Two subjects are before this Division. One is a standard method of drive connections for loading and unloading trucks. The other relates to cooperation with the Tire and Rim Division toward a possible simplified series of truck ratings, and definite standards in regard to tire equipment and capacities.

HEADLAMP GLARE PROBLEM

A DIGEST of existing laws and ordinances relating to headlights in the different states and in several municipalities has been prepared by the Committee on Legislation of the Illuminating Engineering Society. Conferences have been held with legislators and others in connection with the revision of present laws and the enactment of new laws relating to headlighting.

The New York State highway law in relation to lights on motor vehicles was amended in May, 1918. The specifications upon which the amendments were based were prepared by the Committee on Automobile Headlighting Specifications, of which Dr. C. H. Sharp is chairman, in cooperation with the Lighting Division of the S. A. E. It is believed by the I. E. S. Committee on Legislation that the adoption of the provisions made in the amended law will result in the amelioration of conditions in three ways: first, by forbidding undue or dangerous glare resulting from the misuse of otherwise acceptable equipment; second, by condemning equipments which produce a glare that is greater than should in any case be tolerated; third, by setting up a numerical standard according to which the acceptability of headlight devices under the law can be determined by photometric tests.

The specifications for headlight tests were issued by the Secretary of State on June 25, 1918. Copies of the amended law and of the specifications for tests can be obtained upon application to the office of the Secretary of State, Albany.

Adjustment to Conform to New York Requirements

The certificates of approval of automobile headlighting devices which have been issued by the Secretary of State contain certain regulations as to the adjustment of these devices, which must be conformed with in using them on the road. These regulations include first the adjustment of the incandescent bulbs with respect to the focus of the reflector; second, the maximum allowable candlepower of the bulbs to be used therewith, with the headlamps adjusted to give a horizontal beam, and with the headlamps adjusted to give a beam tilted to a certain extent downward toward the road. Not all the devices are subject to all of these regulations, but discussion of all the regulations will cover all cases.

The specifications for headlight tests issued by the Secretary of State state that the law is complied with if the headlamps do substantially the following things:

The beam at a distance of 200 ft. directly ahead of the car and at some point between the road level and 42 in. above it must be at least 1200 cp. (This covers the minimum light for safe driving).

The beam 100 ft. ahead of the car and 60 in. above the level must not exceed 2400 cp. (60 in. is about the height of an oncoming driver's eye above the road and 2400 cp. does not cause an excessive glare when he is 200 ft. or more distant).

The beam 100 ft. ahead of the car, 60 in. above the level surface and 7 ft. to the left of the axis of the car, must not exceed 800 cp. (7 ft. to the left is taken because that represents approximately the position of the oncoming driver when he has turned out to pass, and at this point a low glare limit is necessary for safety.)

The acceptance tests have been made under conditions which involve the fulfillment of these requirements.

Incandescent bulbs at present on the market are of two types: the vacuum or Type B and the gas-filled or Type C. The filament of the Type B is arranged in the form of a small horizontal coil. The filament of the Type C is in the form of a V, which V is made up of a minute spiral of wire. On account of the different shapes of the filaments of Type B and Type C, in many cases a higher candlepower can be used with one type than with the other without exceeding the specified limits of glare.

Status of Glare Problem

At the meeting of the Illuminating Engineering Society held in October, Mr. F. M. Hugo, Secretary of the State of New York, spoke on the glare problem. He said that the two particularly vicious things in automobile highway traffic are the careless or intoxicated driver and the glaring headlamp. The endeavor is to abolish the former and reduce the evil of the latter.

The old New York State law was not enforced efficiently. There was no standard of lighting to follow. Prominent police commissioners said that they could not enforce the law.

The headlamp glare problem is a practical one, Secretary Hugo feels; the bulb and focus must be proper, and the headlamp sometimes tilted. The solution cannot come through figures; there must be cooperation with the motorists and a broad, fair-minded spirit instilled. Educational methods should be followed rather than relief through drastic legislation. The Secretary of State has no power to order the state troopers to enforce the law, but they are cooperating.

The crux of the problem is to get enough light on the highway, but not too much. The candlepower behind the no-glare device has been too little or too great. No headlamp with over 24 cp. has been approved. The lowest commercial headlamp bulb candlepower is 10. In some road tests a 10 cp. bulb could not be seen 50 ft. away, Secretary Hugo said. In this case, 24 cp. was allowed. Four other like cases are under consideration.

The Secretary of State alone has discretionary authority to permit the use of bulbs of greater candlepower than that named in the specifications.

In Ontario there is a blanket prohibition against headlamps having bulbs of more than 24 cp. There is much trouble from excessive candlepower. In other instances adjustment is a cure.

Secretary Hugo feels that there is no more fruitful source of highway accident than the glaring headlamp. He appreciates at the same time that reason must rule and what materials there are at hand must be utilized.

In the lack of existing numerical bases for headlamp specifications the I. E. S. and S. A. E. committees cooperated in making road tests of light required for visibility. Tests were made using photometers, separate storage batteries on the cars to keep the light steady, and rheostats in series.

The elimination of glare is in the discretion of the Secretary of State. The worst of the glare evil will be eliminated, and the road lighting will be pretty good. But a great deal more will have to be done before the automobile headlamp glare problem will have been solved entirely, in the opinion of Dr. Sharp of the I. E. S. Committee.

S. A. E. STANDARD SCREWS AND BOLTS

THE first step toward standardizing the present United States Standards for bolts, nuts and screw threads was accomplished in the Report of the Navy Board made in May, 1868, recommending a United States Standard Gage for Bolts, Nuts and Screw Threads.

On Jan. 19, 1906, the Mechanical Branch of the Association of Licensed Automobile Manufacturers held a meeting in New York City at which the following, among other industrial representatives, were in attendance:

A. L. Riker (chairman), Locomobile Co. of America; George M. Bond, screw thread expert; W. B. Pearson, president, Standard Screw Co.; Henry Souther, metallurgist, Henry Souther Engineering Co.; Hiram P. Maxim, Electric Vehicle Co., and John Wilkinson, H. H. Franklin Mfg. Co.

At this meeting it was decided to establish a series of fine screw-thread pitches for certain classes of work, in response to the demand for uniform practice. The subject was carefully discussed and referred to a Committee on Standard Hexagon Head Screws and Hexagon Nuts, comprising A. L. Riker, H. E. Coffin, H. P. Maxim, Charles B. King, John Wilkinson, Russell Huff, and Henry Souther. This committee reported a series of fine pitch screw threads at the A. L. A. M. meeting held on April 6, 1906. In submitting the detail dimensions, it was said:

"The present United States standards for bolts, nuts and screw threads were established by the United States Navy Department in 1868. These standards remained preeminent for many years and have proved of great convenience and value. During recent years, however, manufacturers of fine machinery have found from experience that for a large portion of their work, United States standards for pitch of threads have been too coarse and the dimensions of heads and nuts too large. In order to secure satisfactory construction, special fine pitch screw threads and smaller nuts have had to be made. The number and variety of these special threads and nuts have finally become such that great confusion, inconvenience and expense have been caused. To overcome this condition, the Association of Licensed Automobile Manufacturers has adopted a new screw standard which is herewith set forth.

"It is assumed that where screws are to be used in soft material, such as cast iron, brass, bronze or aluminum, the existing United States standard pitches will be used."

The detail dimensions and specifications of the screws, castle and plain nuts covered a range of from ¼ to 1 in. diameters inclusive and were known as the Association of Licensed Automobile Manufacturers' standard for hexagon head screws, castle and plain nuts. These dimensions were substantially the same as those now shown in the S. A. E. Handbook, vol. I, page 4 (S. A. E. Screw Standard).

The adoption of the A. L. A. M. screw standard resulted in the ready cooperation of motor car manufacturers and screw makers, and the screws were manufactured and put into use in the automobile as well as in other industries. Good results were realized by those who adopted the finer pitches in order to eliminate the trouble of screws working loose in classes of machinery subject to unusual vibration. A tabulated series of drill and tap sizes was published by the A. L. A. M., corresponding in general to that contained in the S. A. E. Handbook, vol. I, page 4a. The industries were circularized in an endeavor to secure definite information as to the extent to which these newly adopted screw pitches had been used, the result indicating that the series had met with very extensive favor.

In a report made by the late Major Henry Souther in 1908 it was shown that A. L. A. M. standard screw threads were increasing greatly in popularity. One trouble was being experienced, however, due to screw manufacturers not using proper material. One of the original intentions in connection with the A. L. A. M. screw standard specifications was that screws should not be made of soft material, and that by using harder steels smaller screws would be possible for any given work because of increased core strength as well as of material. The first choice at that time was nickel steel specification No. 3 (A. L. A. M. Bulletin No. 33A), with the following chemical composition:

Nickel, not less than 2.50 to 5 per cent (3 per cent desired).

Carbon, from 0.20 to 0.28 per cent (0.25 per cent desired).

Phosphorus, not over 0.04 per cent.

Manganese, 0.60 to 0.90 per cent (0.75 per cent desired).

Sulphur, not over 0.04 per cent.

Vanadium, 0.10 to 0.20 per cent, optional but desirable.

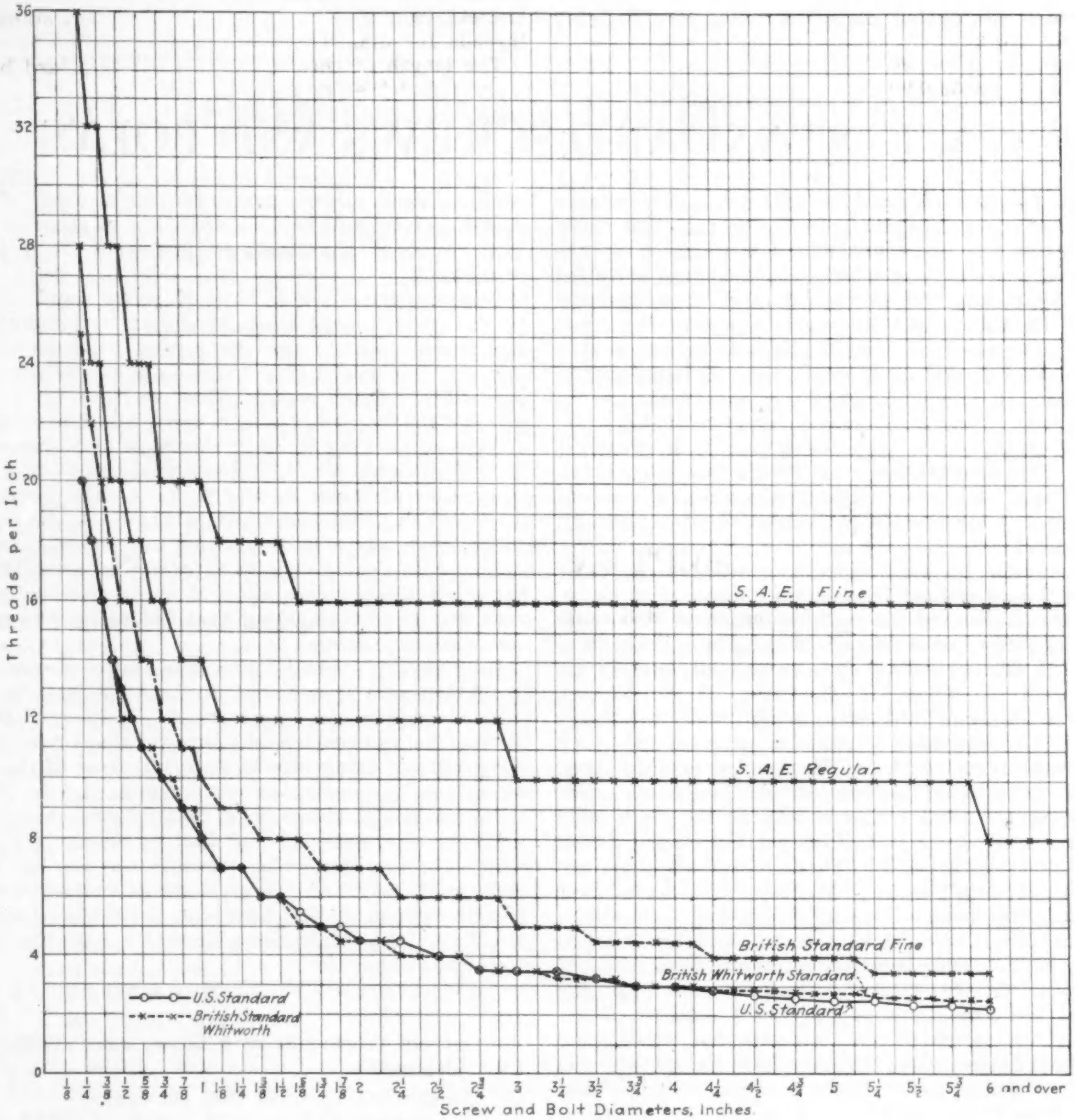
A test specimen of this steel, fully annealed, should show the following physical characteristics:

Tensile strength per sq. in., not less than 85,000 lb.
Elastic limit per sq. in., not less than 55,000 lb.
Reduction of area, not less than 50 per cent.
Elongation in 2 in., not less than 25 per cent.

This steel was then furnished by a few of the steel com-

panies. Second choice was the carbon steel specification No. 4 (A. L. A. M. Bulletin No. 33A), so-called gun-barrel steel of the following chemical composition:

Carbon	0.45 to 0.55 per cent
Phosphorus	0.05 to 0.075 per cent
Manganese	1.10 to 1.30 per cent
Sulphur	0.00 to 0.06 per cent
Vanadium (optional but desirable)	0.10 to 0.20 per cent



COMPARISON OF STANDARD SCREW THREAD PITCHES

The accompanying curves show the thread pitches used in the five Inch-Systems most generally adopted in American and British practice for screws and bolts ¼ inch and larger in diameter. The small crosses (×) or circles (o) on the curves indicate the standard screw and bolt diameters for each system. Where a cross is in a circle on the U. S. Standard or Whitworth curves, it indicates that the size is common to both systems

This steel, as received from the maker, should show the following physical characteristics:

Tensile strength per sq. in. not less than	85,000 lb.
Elastic limit per sq. in. not less than	55,000 lb.
Reduction of area not less than	45.0 per cent
Elongation in 2 in. not less than	15.0 per cent

Nickel-steel screws could be heat-treated or not, as desired, but by giving them the proper heat treatment their strength was increased nearly 50 per cent. The No. 4 steel was not to be heat-treated because of its high carbon and manganese content, and the discontinuance of using soft materials was urged.

There has been some question in connection with the A. L. A. M. (S. A. E.) screws as to the best material to be used. When speedy screw-machine production, permitting rapid removal of metal and a resulting smoothness of finish, are the principal considerations and physical strength and toughness are secondary, the question is at present reduced to deciding between a relatively small difference in the percentage of manganese and sul-

phur in bessemer and open-hearth stocks as indicated in the accompanying tables:

Carbon per cent	Manganese per cent	Phosphorus per cent	Sulphur per cent
0.08-0.16	0.60-0.80	0.09-0.13	0.075-0.15
0.08-0.16	0.50-0.80	0.09-0.13	0.075-0.13

and for open-hearth stock:

Carbon per cent	Manganese per cent	Phosphorus per cent not over	Sulphur per cent
0.15-0.25	0.60-0.90	0.06	0.075-0.15
0.15-0.25	0.50-0.90	0.06	0.075-0.12

The original A. L. A. M. screw standard (S. A. E. Regular) specified steel for all screws and nuts of the following physical properties:

Tensile strength, not less than 100,000 pounds per sq. in.

Elastic limit, not less than 60,000 pounds per sq. in.

In 1913 the S. A. E., believing that the physical properties should not be one of the elements of the standard, eliminated from it all reference to the said physical properties, leaving the specification of material to the individual engineer.

On June 8, 1909, it was decided that an S. A. E. Standards Committee should be established to simplify and coordinate routine engineering practice in the automobile industry. To facilitate this work the A. L. A. M. turned over its standardization work, including established standards, to the S. A. E.

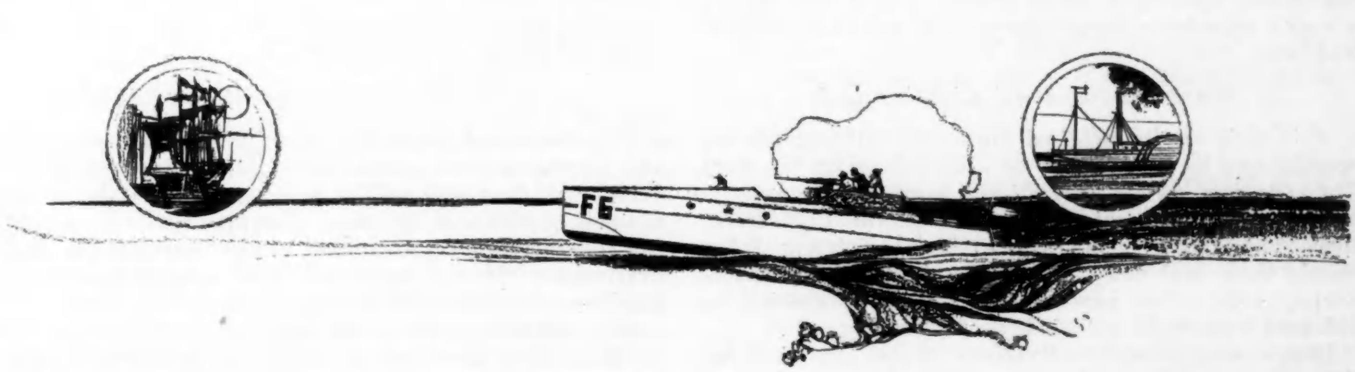
The A. L. A. M. screw standard was adopted without substantial change by the S. A. E. in 1911. The standard was, however, extended to include $1\frac{1}{2}$-in. diameter bolts. The need of a series of pitches for diameters above $1\frac{1}{2}$ in. soon became apparent; consequently, in January, 1915, the present S. A. E. regular pitches for diameters above $1\frac{1}{2}$ in. were adopted. The need for a series of still finer pitches, for hub caps, instrument covers, etc., was met by adopting the present standard fine threads for diameters above $1\frac{1}{2}$ in.

The length of thread for S. A. E. standard bolts was increased at the June, 1916, meeting, as it was found in practice that the effective thread length previously specified was not sufficient where parts bolted together were not machined within limits of 1/16 in. It was also reported that screw makers were inclined to measure the thread to the extreme point marked by the die, rather than to the end of the full thread.

With the rapid development and refinement in airplane construction, a system of fine threads of diameters $1\frac{1}{2}$ in. and under became necessary for fine adjustments and to prevent parts working loose under the peculiar vibrations and other conditions in airplane operation. Consequently, in January of this year the series of fine pitches was extended to include bolts and screws of from $\frac{1}{4}$ to $1\frac{1}{2}$ in. diameters inclusive. These fine pitches are intended for general as well as aeronautic use.

FIELD SECRETARY PLIMPTON ENTERS GOVERNMENT SERVICE

Raymond E. Plimpton, who has been associated with the office of the Society during the last three years, has answered a call to enter the Government service in Washington. Acting in turn as publication manager and field secretary, Mr. Plimpton is a marked example of the young men who have worked hard and grown with the development of the Society. Having a good technical training and a sound general education, he has done editorial work of a superior kind and been of much assistance in the preparation of the publications of the Society, as well as given good service in Section and membership increase matters. He has exhibited unusual power of conception of engineering society activities, having a strong sense of adequate standards, and at the same time due appreciation of improved methods and practices. He carries with him the good wishes and faith of his associates in his new work, which for the present will be in connection with the issuance in proper form of specifications of the Engineering Division of the Motor Transport Corps.



FACTORY LIGHTING

A REPORT of interest to many members was made at the meeting of the Illuminating Engineering Society in October. This was prepared by that Society's Committee on Lighting Legislation, of which L. B. Marks is chairman.

During the past year the work of the committee has been directed chiefly to the Pennsylvania and New Jersey codes of lighting for factories, mills and other work places. These codes were revised early in the year to conform with the revised code of the Illuminating Engineering Society, with special reference to the requirements of intensity of light on the work. At the time of this revision, the suggestion was made by the Department of Labor that the factory inspectors in the two states would welcome any additional technical information that would aid them in enforcing the code. Acting on this suggestion, a course of lectures on the code requirements was given in Philadelphia by Professor C. E. Clewell, of the committee, under the joint auspices of the Pennsylvania and New Jersey Departments of Labor and the University of Pennsylvania. In these lectures the use of the foot-candle meter was demonstrated. Arrangements have since been made for carrying out this plan of lectures and demonstrations in other states.

New York Industrial Lighting Code

After deliberations extending over the period of a year, the New York State code of lighting for factories and mercantile establishments was adopted and became effective July 1, 1918. In general, the provisions follow closely those of the Illuminating Engineering Society code, the chief differences being as follows: The New York State code specifies a minimum of 1.00 foot-candle (instead of 1.25 foot-candles) for rough manufacturing operations and includes an additional subdivision of 0.50 foot-candle for work not requiring discrimination of detail; it specifies a minimum height of 20 ft. for unshaded lamps except where such lamps are used for a temporary decorative purpose; it specifies a minimum of 0.25 foot-candle for emergency lighting. The foregoing requirements are mandatory. In an appendix to the code is given a table of minimum intensities proposed for several hundred industrial operations and processes. This classification is tentative, but the Industrial Commission proposes to make these intensity requirements mandatory on July 1, 1919, if after public hearing and a year's experience these values are found to be adequate and just.

Wisconsin Industrial Lighting Code

This code in its original form did not contain any specification as to intensity of illumination on the work. The code was revised in 1918 and now contains requirements both for natural and artificial illumination intensities. The requirements for artificial lighting follow closely those laid down in the Illuminating Engineering Society code. Two new General Orders of special significance have been included, as follows:

Lamps suspended at elevations above eye level less than one-quarter their distance from any position at which work is performed, must be shaded in such a manner that the intensity of the brightest square-inch of visible light source shall not exceed 75 candlepower.

Exception: Lamps suspended at greater elevations than 20 ft. above the floor are not subject to this requirement.

Lamps for local lighting must be shaded in such manner that the intensity of the brightest square-inch presented to view from any position at which work is performed, shall not exceed 3 candlepower.

The Industrial Commission proposes to try out these regulations and to modify them as experience may dictate.

Insurance Rating Schedule in Factory Lighting

Conferences were held with insurance companies and with the Workmen's Compensation Bureau, looking to the establishment of standards for factory lighting in the rating schedule. Up to the present time, the intensity of illumination on the work has not been accepted by the insurance underwriters as a basis for rating factory lighting installations. The sub-committee in charge of this matter made the following recommendation:

The foot-candle method for establishing factory illumination standards should be used, making readings with a foot-candle meter or similar device; ¼ foot-candle intensity, 30 ft. from the floor should be designated as a minimum standard for accident prevention lighting in aisles, passageways, stairways and other open parts about a shop where employes are obliged to travel.

It is pointed out by the sub-committee that exception should be made in certain industries, such as founding, and in buildings having dark floors and walls where ¼ foot-candle is too low. A higher intensity up to 1 foot-candle is desirable in such cases.

Safety Codes

The Committee cooperated with the American Museum of Safety, the U. S. Employes Compensation Commission and the Bureau of Standards in connection with a safety code subsequently prepared by the Bureau of Standards for the safety engineers of Federal arsenals and navy yards. The lighting provisions of this code, recently issued, are based upon those in the revised factory lighting code of the Illuminating Engineering Society.

Further cooperation with the Bureau of Standards is now in progress in connection with the National Electrical Safety Code requirements for the illumination of subways, switchboard rooms, power stations and substations, storage-battery rooms, and other places where electrical equipment is operated.

Work of the Divisional Committee on Lighting

The Divisional Committee on Lighting was created by the Committee on Labor (including Conservation and Welfare of Workers) of the Advisory Commission of the Council of National Defense. The members of the lighting committee were nominated by the Illuminating Engineering Society and appointed by Mr. Samuel Gompers, Chairman of the Committee on Labor.

The scope of work of the lighting committee, as set forth by the Committee on Labor, is to assist in maintaining and improving the working and living conditions of industrial and public employes from the standpoint of lighting. To this end the lighting committee, shortly after its appointment last year, submitted to the Committee on Labor a code of lighting for factories, mills

and other work places, abstracted from the revised code of the Illuminating Engineering Society. This code was accompanied by a prefatory note setting forth the advantages of maintaining high standards of lighting in industrial establishments. The first edition of this code was printed and published by the Committee on Labor, Washington, in April, 1918. Copies of this pamphlet have been placed in the hands of the labor and industrial commissioners of the various states with a view to ultimately putting the code into operation in every state in the Union. To carry out this program most expeditiously, a representative of the Divisional Committee on Lighting was selected for each state. Appointments of state representatives have been made for thirty-five states.

The proposal to introduce this code has met with favor in most of the states, and in several the legislative enactment of the code is now under consideration; as a rule, however, the state industrial boards have been reluctant to advocate legislative enactment until the rules have been tried out in practice for a longer period of time. The experience of Pennsylvania, New Jersey, Wisconsin and New York, where industrial lighting codes are in force, will serve as a guide to other states.

The state representatives have conducted a local campaign of education as to the need of the code and have cooperated directly with the commissioners of labor and industry in their respective states. The code has been circularized among manufacturers, and in some states illustrated lectures have been given to more fully elucidate the principles upon which it is based. The rules of the code have been published in many technical and trade publications throughout the country. The members of the committee have also cooperated with the War Service Committee in effectively distributing the pamphlets on protective lighting.

NATIONAL SCREW THREAD COMMISSION

RECENT meetings of the National Screw Thread Commission were attended by, among others, Dr. S. W. Stratton (chairman), Bureau of Standards; Lieut.-Col. E. C. Peck, Ordnance Department; Major O. B. Zimmerman, Engineer Corps; E. H. Ehrman, S. A. E.; James Hartness, A. S. M. E., and F. O. Wells, A. S. M. E.

The matter of extending the organization of the Commission in the way of associating with it various authorities on screw threads from industries and other sources was discussed, and it was decided to add to the four committees formed at the initial meeting on Sept. 12 various sub-committees or groups.

The following groups were suggested:

1 U. S. Standard.
2 Fine Threads.
3 Classification.
4 Tolerances.
5 Specification and Testing.
6 Machine Screws.
7 Pipe Threads.
8 Hose Couplings.
9 Brass Tubing.
10 Brass Goods.
11 Acme and other specials.
12 Miscellaneous (bicycle spokes and other special threads).
13 Instrument Threads.

In connection with the consideration of threads cut on wire, it was suggested that the matter of wire gages be considered and standards adopted for these.

The chairman stated that in his opinion meetings should be held in various industrial centers, such as New York City, Dayton, and Detroit, as well as Washington. The purpose of meeting in Washington would be to get the authorities together from the various Government departments and secure their viewpoints and such data as they may have.

A public hearing was held in New York City in October at which manufacturers and users of certain classes of threaded products were invited to give testimony in regard to the present practice in screw-thread manufacture, and to suggest the lines along which standardization should proceed.

The following topics were given consideration:

1 As a national standard, is there any objection to the continuation of the U. S. Standard System of thread diameters and pitches for general use in practically its present shape?

2 As a national standard, is there any objection to the adoption of the S. A. E. System of diameters and pitches of fine threads?

3 As a national standard, to what extent could the A. S. M. E. System of standard machine screws be adopted?

4 There seems to be a general feeling that in standardization it should be possible to cover several classes of work, and there has been suggested a minimum of four classes of fits to provide for different grades of work, ranging from reasonably wrench-tight fits to very loose fits. Would such a classification, including at least four classes, be sufficient for all grades of work encountered in the various systems of threads previously mentioned, or would a classification including more than four classes be required?

5 Is there any objection to adopting the "Standard hole" practice for screw threads; that is, the practice of making all the taps for any particular thread of one basic size and securing the required fit by changing the diameter of the screw or male threaded work which is to assemble with the nut cut by the basic tap?

The consensus of opinion of those present was as follows:

(1) The U. S. System should be continued practically in its present form for the ordinary threaded work, to which it is well adapted.

Objections were raised to its use for diameters less than half-inch on the ground that for small work the U. S. pitches are too coarse and the threaded work too much weakened by excessive depth of thread.

(2) The S. A. E. System is satisfactory for use where finer threads are necessary, as for example in automobile and aeroplane work.

(3) The A. S. M. E. System should be used to supplement the U. S. System for diameters less than quarter-inch, and all sizes from 14 to 30 should be discontinued in order that there may be no overlapping of the two systems. A minority thought that all A. S. M. E. sizes should be retained.

(4) Classification of Fits

The general opinion was that four classes of fits would be ample to provide for all ordinary threaded work, and that very probably three classes would be sufficient, wrench fits, stud fits, etc., which could not be covered by general specifications, being classed as "special" and no attempt made to include them in the regular classification.

(5) Standard Hole Practice

There was a sharp difference of opinion on the question whether the nut or the screw should be made basic, with a majority favoring the former.

A part of the objection to making the hole basic arose from a misapprehension. It was suggested that if the tap or the tapped hole were made basic, it would be necessary to carry in stock several sizes of bolts in order to provide for different classes of fits. This is not, however, the case, since in general only a single class of fit will apply to each threaded product and only that class would be carried in stock. For example, machine screws should be made within certain tolerances, while bolts for agricultural machinery would require larger tolerances and there would be no necessity for providing for machine screw fits on agricultural machinery bolts, or for "agricultural fits" on machine screws.

AMERICAN-BRITISH GAGE BUREAU

MAJOR H. W. TORNEY, U. S. A., and Mr. H. J. Bingham Powell, of England, have charge of the U. S. Bureau of Aircraft Production Section of Gages and Standards, and the Gage Inspection Department of the British War Mission, located in New York City. This highly important and very advanced combined organization is installed at 45th Street and Madison Avenue. Here gages are designed, purchased and inspected.

All new gages are sent to this bureau, inspected and returned to the particular districts in which they are used. Formerly district officers had discretionary power to use in certain classes of work gages rejected for given specific purposes, but this practice has been discontinued; once a gage is rejected, that is the end of it.

Visits are made to the war products plants fortnightly to examine for wear the gages in use there. The history of each gage is recorded in books at the respective factories, the inspectors noting down the result of each periodical examination of them. The use of any gage is discontinued after it develops an amount of wear that has been predetermined.

The United States Army has received greatly appreciated assistance from the British in the establishment and operation of this branch of its inspection work. Nearly one hundred persons are employed in the laboratory at this time. There is an adequate drafting room for the design of the gages. The basic purpose of the bureau is to aid manufacturers in production and facilitate their meeting the gages in their work. That is, the activity is gage procedure in the broad sense, much of this practice being based on reports of the National Physical Laboratory of London. Clear instruction in the use of gages is given. A branch is maintained in Detroit.

Conflict of Thread Standards

The matter of the international conflict of thread pitches is of course before the bureau much of the time. This is one of the subjects that was considered in a preliminary way at the conference of American and British engineers held early in the year in London in cooperation with the work of the British Engineering Standards Association for the determination and promulgation of mechanical standards for the British Government.

The British representatives here feel that if a series of screw or bolt pitches could be agreed upon by Great Britain and this country, the rest of the points in connection with thread practice that would have to be solved would be easy of disposition. For example, the difference in the specifications for the Whitworth and for the United States forms of thread is not considered formidable. In other words, they are of the opinion that in practice the United States form of thread is produced rounded in a way approaching that specified in the Whitworth standard. The view has been expressed that the five-degree difference in the angle of the British and of the United States thread is not an insurmountable obstacle to Anglo-American standardization. U. S. nuts have been assembled on Whitworth screws without great "over-wrenching" in the great majority of cases in recent trials made.

There is a strong tendency in England to replace the Whitworth pitches by the British standard fine pitches. These latter run numerically about half-way between those of the United States standard and of the S. A. E. Standard Regular. Some of the British engineers make the statement that the British standard fine pitches will answer the needs of all engineering practice. They are anxious that an Anglo-American standard of pitches shall be established.

The British Association threads are dimensioned in the metric system. This system, which originated in Switzerland, runs up to a little over 1/4 in. diameter, and is used in instrument making.

Gage Inspection

In the American-British laboratory here women are employed extensively. They are found to be good on automatic work. In some of the gage testing machines, a system of wires under weight tension is used, electric visual signals flashing out when a given dimension on a gage is as it should be. Generally speaking, each dimension is measured by a separate person. The establishment is equipped with gage blocks accurate within a few ten-thousandths of an inch. Measurements to two hundred-thousandths are made.

The gage tolerances are usually in amount one-tenth those of the product.

In the case of a complicated gage, like that for an oil-pump, two days are needed for inspection.

The lantern screen system of magnified measurement is used, photographic views of gages thrown on the screen being made. The merit of the work depends, of course, upon the field accuracy of the lens used. Photometric gages will replace steel gages to some extent.

A study is being made of the polarized light method of indicating distribution of stresses, in celluloid pieces cut to shape. It is known in a general way that in the case of threads the stresses are applied on the first few threads only, the most stress being imposed on the first. From this it is deduced that there is no advantage in long threads, unless differentiated threads are used on bolt and nut, the latter being pulled up by a wrench.

PERSONAL NOTES OF THE MEMBERS

Vincent Bendix, of the Eclipse Machine Co., Elmira, N. Y., is now in the Chicago office of this company, 327 South La Salle Street.

Joseph Berg, formerly mechanical engineer, Champion Ignition Co., Flint, Mich., is now manager of the aircraft division in the same company.

O. C. Bornholt, formerly factory manager, Holley Brothers Co. of Detroit, is now mechanical engineer of the Buick Motor Co., Flint, Mich.

L. W. Brownrigg, formerly partner in the R. B. Randall Electric Co., Kansas City, Mo., is now with the National Carbon Co., Inc. of Cleveland.

E. P. Chalfant, formerly Eastern division manager of the Detroit Anderson Electric Car Co., with an office in New York City, is now general manager of the Automotive Products Corp. of New York City.

C. A. Shayne, formerly student at the Massachusetts Institute of Technology, Cambridge, is now junior mechanical engineer with the National Advisory Committee for Aeronautics, Washington, D. C.

David F. Crawford, formerly designing engineer, Lyons Atlas Co., Indianapolis, now holds the same position with the Midwest Engine Co. also of Indianapolis.

Stephen A. Douglas, formerly special sales department representative of the Stewart-Warner Speedometer Corp., Chicago, is now Washington representative for the King Motor Car Co., the Stewart-Warner Speedometer Corp., and the Wilson Welder & Metals Co.; office at 1469 Harvard St., Washington.

Frederick S. Ellett, formerly mechanical engineer, Elmira, N. Y., is now general manager of the Ward LaFrance Motor Truck Co. of Elmira Heights, N. Y.

E. G. Gunn, formerly production engineer of the Aluminum Castings Co., is now assistant engineer of the Packard Motor Car Co. of Detroit.

Mark Harris, formerly engineer of the General Motors Corp., Detroit, is now chief engineer of the Scripps-Booth Corp., Detroit.

Kenske Hashimoto, formerly aeronautical engineer of the Parisano Aerial Navigation Co. of America, is now stationed at 272 Boylston Street, Boston.

F. J. Jarosch, formerly chief engineer of the Bearings Co. of America in Lancaster, Pa., is now secretary and manager of the Liberty Engineering Co., Inc., same city.

R. B. Jones, formerly superintendent of engineering shops, Curtiss Aeroplane & Motor Corp., Buffalo, is now production engineer of the Canadian Aeroplanes, Ltd., Toronto, Canada.

L. Edward Lentz, formerly superintendent and assistant treasurer, General Vehicle Co., Long Island City, N. Y., is now manager of service and supply departments, in the Elliott-Fisher Co., Harrisburg, Pa.

Courtney N. Mitchell, formerly chief engineer, The Deneen Motor Co., Cleveland, is now chief engineer of the truck division, Grant Motor Car Corp., in the same city.

B. Nikiforoff, formerly engineer in the Remington Arms Union Metallic Cartridge Co., Bridgeport, Conn., is now established as a mechanical engineer in New York City.

John W. Oswald, formerly with the Hamilton Motors Co., Grand Haven, Mich., is now general manager of the Napoleon Motors Co., Travers City, Mich.

Austin P. Palmer, formerly electrical consulting engineer in New York City, is now electrical tester with the Sperry Gyroscope Co. of Brooklyn, N. Y.

G. H. Peterson, formerly designing engineer of the Champion Ignition Co., Flint, Mich., is no longer connected with that company.

H. H. Pinney, formerly vice-president, Remington Arms Union Metallic Cartridge Co., Bridgeport, Conn., is now with the Peters Cartridge Co. in Cincinnati.

L. C. Reynolds, formerly with the Oakland Motor Car Co., Pontiac, Mich., is now manager of the motor factory of the General Motors Corp. in Detroit.

Chester S. Ricker, formerly consulting engineer in Indianapolis, is now with Evans-Winter-Hebb, Inc. of Detroit.

M. R. Riddell, formerly director of testing and research in the Canadian Aeroplanes, Ltd., Toronto, Canada, is now chief engineer with same company.

Arthur M. Robbins, formerly general manager of the Chalmers Sales Co., New York City, is now with the 167th St. Garage Co., Inc., New York City.

M. H. Roberts, formerly manager of Meade Johnson & Co., Evansville, Ind., is now chief engineer in the Air Reduction Co. of New York City.

James Ross, formerly chief engineer of the The Bullock Tractor Co., Chicago, is now a designing tractor engineer in that city.

J. T. Sandwich, formerly manager of purchasing and advertising for the Tulsa Automobile Corp., Tulsa, Okla., is now in the purchasing department of Reed & Glaser, Indianapolis.

C. T. Schaefer, formerly chief engineer and factory manager of the Globe Motor Truck Co., St. Louis, Mo., is now chief engineer in the Arvac Co., Anderson, Ind.

H. W. Simpson, formerly inspector of aviation engines, Inspection Section, Equipment Division, Signal Corps, Detroit, is now assistant engineer with Henry Ford & Son, Detroit.

John Squires, formerly consulting engineer and vice-president of the Signal Motor Truck Co., Detroit, is now president and general manager of The Squires Engineering Corp. of that city.

John Swinscoe, formerly chief engineer with Crown Cork & Seal Co., Baltimore, Md., is now industrial engineer in the Wright-Martin Aircraft Corp., New Brunswick, N. J.

Frank M. Taylor, formerly purchasing agent in The Glenn L. Martin Co., Cleveland, is now director of purchases for The Parish & Bingham Co., that city.

H. Wilton Topley, formerly mechanical engineer, Good Inventions Co., Brooklyn, N. Y., is now engineer in the Militor Corp., Jersey City, N. J.

J. R. Van Dyke, formerly at Mercersburg Academy, Mercersburg, Pa., is now assistant secretary, Y. M. C. A., Army Base Hospital 11, Camp May, N. J.

R. O. Watson, formerly consulting engineer, Smiths Static Motor, Ltd., London, Eng., is now with the Militor Corp., Jersey City, N. J.

L. E. Wood, formerly assistant chief engineer, Mitchell Motors Co., Racine, Wis., is now engineer for the Marwin Truck Corp., Kenosha, Wis.

A. H. Wyatt, formerly financial manager of The Automotive Corp., Chicago, is now president and general manager of same company in Ft. Wayne, Ind.

Joseph Zagora, formerly designer and engineer, Mitchell Motors Co., Racine, Wis., is now designing and production engineer for the Anderson Motor Co., Rock Hill., S. C.

WILLIAM KENT

THE announcement of the death of William Kent was a shock to the entire engineering profession. He passed away at his summer home in Ganaonoque, Ont., after a few hours' illness. While at his age most men are looking ahead with such philosophy as their training may have brought, into the "great unknown," to his friends he had lived a life of such incessant and varied activity that the idea of death had not been associated with him.

Dr. Kent was born in Philadelphia in 1851 and studied in the schools there until he passed out of the Central High School. He was for years a student in evening classes at Cooper Union. He was graduated from Stevens Institute of Technology in 1876.

Dr. Kent made several ventures into active business life, first with the Jersey City Gas Co. and the Cooper Hewitt Co., while still an undergraduate; later on with the Schoenberger Steel Co., the Springer Torsion Balance Scale Co., the Sandusky Foundry & Machinery Co., and the Babcock & Wilcox Company. While with the last named company he was transferred to the New York office. During this period he took out many patents on boilers, furnaces and boiler accessories, weighing machines, gas producers and other combustion and labor-saving appliances. He came to be regarded as an authority on steam boiler practice. His experience as superintendent or general manager of large manufacturing and producing firms was turned to good use by him in his many articles in the technical press, books and the hundreds of lectures he delivered at several universities. He was an earnest advocate of scientific management, being one of the charter members of the Taylor Society. His activities as editor, teacher and lecturer covered more than a score of years, beginning in 1877, when he assumed duty as editor of *American Manufacturing & Iron World* of Pittsburgh. Later on he became associate editor of *Engineering News*, New York City. For several years he acted as contributing editor to *Industrial Engineering*.

Dr. Kent will be best remembered for his Mechanical Engineering Pocket Book, which came out in 1895 and has now reached its tenth edition. It has been for many years the "Bible" of the mechanical engineer.

On the social side of life Dr. Kent showed his appreciation of the value of fellowship, William Morris' definition of Heaven. He was a member of many engineering societies, a charter member and vice-president of the American Society of Mechanical Engineers, and president of the American Society of Heating and Ventilating Engineers. He was a member also of the Engineers' Club of New York City and of the Technology Club of Syracuse. From Syracuse University, where he remained as Dean of mechanical engineering in the College of Applied Science until 1907, he received the degree of Doctor of Engineering.

Lieut. Lindsey F. Campbell, of the 4th Battery, 2nd P. T. R., was killed in action on the front in France on the 10th of August.

Lieutenant Campbell, a Junior Member of the Society since December, 1915, was born in Detroit, Mich., in 1892. He was educated in Chicago at the famous John Dewey School and the University High School. In 1910 he entered Michigan University and was graduated in 1914 from the mechanical engineering department. During his vacations, Lieutenant Campbell placed some shop work to his credit before doing his university work, and immediately on leaving the University, took a position with Dodge Brothers in Detroit, where he remained until he entered the service, in August, 1917. He was trained at Fort Sheridan, received his commission in November, and on the 9th of the following January arrived on the other side. There he was assigned to the 18th Field Artillery with the 2nd Division of the American Army, and as part of his training spent three weeks at the front making observations, and also took the course at headquarters in the Gas School. Early in July he was sent to the front "where the guns never cool," and was in the hut assigned to the officers when, on the 10th of August, the Germans sighted the spot and bombed it. He was wounded and died a short time later in the Evacuation Hospital. He has been buried in the American Cemetery near Château-Thierry.

Lieutenant Philip J. Davidson was killed in action on the 5th of August. Lieutenant Davidson was born in May, 1887, in Beaver Falls, Pa. He was educated in his home town and the University of Pennsylvania, and immediately entered the Union Drawn Steel Works for practical training. He passed rapidly from one department to another until his knowledge of the business covered its details through production, organization and finance.

He was holding the position of treasurer of this company and secretary and treasurer of the Ideal Tool and Manufacturing Company, of his home town, when he entered the service.

He became an Associate of the Society on Sept. 8, 1915.

Activities of S. A. E. Sections

THE season's activities of the Sections, the opening guns of which were the Cleveland and the Detroit meetings in September, were much interfered with last month by the influenza epidemic. The meetings planned for October by the Buffalo, Cleveland, Detroit, Mid-West and Pennsylvania Sections were postponed by health department orders or other good reasons due to the "flu."

At the September meeting of the Detroit Section the following were appointed to assist in the formulation of headlamp glare legislation, at the request of Governor Sleeper of the State of Michigan: W. E. Metzger, C. E. Godley, J. B. Replogle, H. J. Platz, and F. E. Watts.

A Highway Transport meeting was held by the Metropolitan Section on Oct. 16. Mr. S. W. Fenn, of the National Automobile Chamber of Commerce, addressed the members on rural motor express development and possibilities. Mr. George H. Pride, a member of the Highways Transport Committee of the Council of National Defense, and chairman for the district in which New York City is located, explained the efforts that are being made to bring about a state of efficiency on the highways, relieving congestion on rail and water routes, and not using the highways unnecessarily. He announced that the store-door delivery system will be inaugurated by Railroad Administrator McAdoo in New York and other cities soon.

On Nov. 2 the members of the Metropolitan Section will visit the plant of the Wright-Martin Aircraft Company at New Brunswick, N. J. They are to be the guests at luncheon of Vice-president George H. Houston, of the Society, and Henry M. Crane.

Early in October W. G. Clark presented at the Minneapolis Section a paper on Carbureter Air Cleaners. Interesting slides were exhibited to indicate the amount of dust in which a farm tractor operates under average conditions.

The subject at the November meeting of the Minneapolis Section, which is scheduled for the 13th, is Antifriction Bearings, Types and Their Advantages. Discussion will be presented by representatives of several bearing manufacturers. The very heavy bearing strains to which tractors are subjected will be given primary consideration, tractors being the principal engineering interest of the Minneapolis Section members.

The Minneapolis Section has settled upon its program of professional sessions for the whole season, dates having been determined for monthly meetings up to and including May. The subjects include Tractor Drawbar Implements, Radiator Cooling Fans, Governors for Tractor and Truck Engines, Tractor Service and Sales, Implements for Tractor Belt Power, and Track-laying Types of Tractor. It is planned also to have addresses given from time to time by men engaged as instructors at the Army and Navy Aircraft Schools, two of which are located at Minneapolis.

Proposed Washington Section

The formation of a Section of the Society in Washington has been under discussion for some time. A preliminary organization meeting to this end has been held there. A gathering of the members resident in Washington will be held on Nov. 13, a number of prominent government representatives being present. Officers directing important work for the Government will be asked to state their automotive engineering problems to the members. It is desired that as many as possible of the S A. E. members residing throughout the country attend this session. The meeting will start promptly at 8 o'clock in the auditorium on the main floor of the new Interior Department Building. Use center entrance on F Street side, between Eighteenth and Nineteenth Streets, N. W. There will be war movies and a very interesting program.

It is the expectation that the S. A. E. members located in Washington, of whom there are nearly two hundred, will hold professional meetings or social gatherings, or a combination of these, at stated periods or on short notice. A great many engineers will remain in Washington after the war. The Government, of course, realizes more and more the value of engineering work in war. In a large sense, war is competition of engineering skill. There are many government engineers who would welcome assistance in conference on difficult problems they are studying. Further cooperation between different branches of the service would be of great value. Official problems could not, of course, be discussed openly.

Very often there is unnecessary duplication of research. Many problems, it is obvious, are common to distinct types of apparatus, airplane and tanks, for example, in the case of sand getting into the engine in some territories as a result of air-current effect. The topical subjects involved in the broad field of war requirements are almost endless. The Society will give service in this connection and hold meetings in Washington at which matters of unusual interest will be presented.

CHAIRMAN BEECROFT ON MISSION ABROAD

CHAIRMAN DAVID BEECROFT, of the Meetings Committee, is contemplating a trip abroad with a party of journalists. The purpose of the visit, which will extend over several weeks, is to enable men connected with prominent trade periodicals published in this country to acquire more complete and accurate information regarding conditions abroad at this time, and to become better acquainted with those engaged in fields analogous to their own in Great Britain, France and Italy.

Service Directory of Members

October Additions—Military

Addis, Charles M., A. E. F., France.

Bishop, Charles D., chief mechanic, Battery C. 33rd Regiment Field Artillery, Camp Meade, Md.

Clark, H. H., Army Training Detachment, Brenan School, Chicago.

Currie, Carleton H., Student Army Training Corps, Michigan Agricultural College, Lansing, Mich.

De Turk, L. M., second class musician, 312th Field Artillery Band, Headquarters 79th Division, A. E. F., France.

Frudden, C. E., captain, Motors Division, Quartermaster Corps, New York City.

Geistert, Albert G., Naval Aviation Engineering Division, U. S. N. R. F., Washington.

Hall, O. W., Motor Instruction Dept., Ordnance Corps, Raritan Training Camp, Metuchen, N. J.

Haskins, Howard B., chief machinist's mate, Naval Steam Engineering School, Stevens Institute, Hoboken, N. J.

Hayes, Ralph S., first lieutenant, Quartermaster Corps, Washington.

Hirtzel, Clement H. A., major, Royal Air Force & Aircraft Production, London, England.

Hodgkins, Merton O., Air Service, Washington.

Hunt, Charles E., machinist's mate, Naval Operating Base, Co. 1142, Hampton Roads, Va.

Kegerreis, Claude S., 16th Co., 4th Battalion, 159th Depot Brigade, Camp Taylor, Ky.

Knauer, C. H., 7th Co., 161st Depot Brigade, Camp Grant, Ill.

Koeckert, Albert E., draftsman, Nitrate Division, Ordnance Corps, Washington.

Lauth, Fred P., machinist's mate, aviation, U. S. N., Washington.

Lincoln, C. W., Aircraft Mechanics Training School, St. Paul, Minn.

Lipps, Walter M., private, 27th Co., 3rd Regiment, 159th Depot Brigade, Camp Taylor, Ky.

Miller, C. S., private, Co. D., 315th Ammunition Train, A. E. F., France.

Mills, Marshall F., captain, Air Service, A. E. F., France.

Mock, Clark L., A. E. F. France.

Risch, Charles H., Army Training Corps, Columbia University, New York City.

Spice, Charles G., captain, Production Division, Ammunition Section, Ordnance Corps, Washington.

Sutherland, Edwin M., ensign, 10th Regiment, Submarine Unit, Pelham Bay, N. Y.

Templeman, R. B., first lieutenant, Engineering Division, Motor Transport Corps, Washington.

Wagner, A. F., first lieutenant, Motor Transport Corps, Baltimore, Md.

October Additions—Civilian

Acker, Emil W., metallurgical engineer, Ordnance Corps, Washington.

Barton, George K., fuel oil combustion engineer, U. S. Fuel Administration, Book Bldg., Detroit, Mich.

Brown, Will H., aeronautical mechanical engineer, Bu. of Construction and Repair, Navy Department, Washington.

Brownrigg, L. W., cost approving supervisor, Ordnance Corps, Morgan Engineering Co., Alliance, Ohio.

Burton, Ralph B., automotive engineer, Motor Transport Corps, Washington.

Chase, Julian C., Superior Motor Truck Corps training school, Winona Lake, Ind.

Conant, William P., inspector, airplanes and engines, Bu. of Aircraft Production, Wright-Martin Aircraft Corp., New Brunswick, N. J.

Elfes, H. L., inspector of airplanes and engines, Bu. of Aircraft Production, Detroit, Mich.

Ericson, John, designer, National Advisory Committee for Aeronautics, Washington.

Gamble, D. Edwin, experimental engine design, Air Service, McCook Field, Dayton, Ohio.

Gundry, Eldon P., checker, Motor Transport Corps (mail) Lieut. Reynolds, 404 Washington Arcade, Detroit, Mich.

Hanks, M. W., aeronautical mechanical engineer, Bureau of Construction and Repair, Navy Dept., Washington.

Hunt, Charles E., machinist's mate, Naval Operating Base, Co. 1142, Unit S, Hampton Roads, Va.

Keagy, George H., production engineer, New York, Shipbuilding Corp., Camden, N. J.

Plimpton, R. E., Specification Section, Engineering Division, Motor Transport Corps, 358 Union Station, Washington.

Schwab, Charles M., aeronautical mechanical engineer, Bu. of Aircraft Production, New York City.

Warner, A. A., aeronautical mechanical engineer, Bu. of Aircraft Production, Detroit, Mich.

Waterhouse, H. D., production engineer, Ordnance Corps, Bridgeport, Conn.

Watson, J. W., assistant chief, Hispano-Suiza Section, Bu. of Aircraft Production, New York City.

Applicants *for* Membership

The applications for membership received between Sept. 18 and Oct. 15, 1918, are given below. The members of the society are urged to send any pertinent information with regard to these names which the Council should have for consideration prior to their election. It is requested that such communications from members should be sent promptly.

ACTON, MICHAEL J., works and factory manager, Lapointe Machine Tool Co., *Hudson, Mass.*

AUTENRIETH, GEORGE C., assistant professor of machine design, College of the City of New York, *New York City.*

BALL, GARRISON, manager, Cleveland District Office, American Bronze Corp., *Berwyn, Pa.*

BECK, HAROLD MACKNIGHT, executive charge of construction and operating departments, The Electric Storage Battery Co., *Philadelphia.*

BOULCOTT, WILLIAM C., sales engineer, Dayton Engineering Laboratories Co., *Dayton, Ohio.*

BREULS, HAROLD EDGAR, testing engineer, Canadian Aeroplanes, Ltd., *Toronto, Canada.*

BROWN, P. W., shop foreman, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

CHAMINADE, LEON A., engineer, Research Laboratory, Studebaker Corp., *Detroit, Mich.*

COLES, WILFRED G., chief engineer, Madison-Kipp Lubricator Co., *Madison, Wis.*

COPEMAN, L. G., president, manager, Copeman Laboratories, Inc., *Flint, Mich.*

DARROW, BURGESS, experimental engineer, Goodyear Tire & Rubber Co., *Akron, Ohio.*

DODGE, ADIEL Y., service manager, Wright-Martin Aircraft Corp., *New Brunswick, N. J.*

DOERR, ARCHIBALD LLOYD, district manager Pacific Coast, The Clyde Cars Co., *Clyde, Ohio.*

FERRIS, H. L., service manager, Autocar Sales Co., *New York City.*

FISK, LOUIS CLARENCE, assistant engineer, Hyatt Roller Bearing Co., *Detroit, Mich.*

FOSS, BENJAMIN S., director, asst. treasurer, secretary, manager, Aeronautical Dept., B. F. Sturtevant Co., *Hyde Park;* director, vice president Sturtevant Aeroplane Co., *Jamaica Plains, Boston.*

GIERN, JAMES B., president, Giern & Anholtt Tool Works, *Detroit, Mich.*

GOSSETT, P. L., tool crib foreman, Premier Motor Corp., *Indianapolis, Ind.*

HAUSER, GEORGE HENRY, JR., head of Engineering Information Dept., Curtiss Engineering Corp., *Garden City, L. I., N. Y.*

JAMISON, EDGAR, proprietor, owner, Jamison Steel Co., *San Francisco, Cal.*

JOHNSTON, RODERICK L., chief metallurgist, Doehler Die Casting Co., *Toledo, Ohio.*

LEWIS, FRANK H., chief engineer, Bean Spray Pump Co., *San José, Cal.*

LODEWYCK, ARTHUR G., lieut., Bu. Aircraft Production, Production Engineering Dept., *Dayton, Ohio.*

LUNDANE, G. R., carburetor engineer, Findeisen & Kropf, *Chicago.*

LYMAN, W. H., general superintendent, Warner Gear Co., *Muncie, Ind.*

MCNULTY, G. HAROLD, draughtsman, Ordnance Dept., Engineering Division, Motor Equipment Section, *Indianapolis.*

MACAULEY, D. L., electrical engineer, National Advisory Committee for Aeronautics, *Washington.*

MILLINS, T. DEWITT, lieutenant-colonel, Air Service, A. E. F., *France.*

MOTHERWELL, GEORGE W., Naval Reserve Forces, 15th Regiment, Aviation Field, *Great Lakes Station, Ill.*

OLIVER, WILLIAM J., president, W. J. Oliver Mfg. Co., *Knoxville, Tenn.*

PACK, CHARLES, chief chemist, Doehler Die Casting Co., *Brooklyn, N. Y.*

PANFIL, ANTHONY C., student, University of Michigan, *Ann Arbor, Mich.*

REID, JOSEPH B., senior inspection, Bu. of Aircraft Production, A. E. F., *France.*

ROBERTS, WILLIAM HENRY, manager, Roberts Storage Battery Co., *New York City.*

SAKUYAMA, YEIKICH, designer, Premier Motor Corp., *Indianapolis, Ind.*

SANDEMAN, W. S., technical road man, Findeisen & Kropf Mfg. Co., *Chicago.*

SHUTT, WALTER H., H. J. Koehler Motors Corp., *Newark, N. J.*

STRYKER, CARLETON E., U. S. N. Aviation Corps, *Los Angeles, Cal.*

TAYLOR, CHARLES F., lieutenant, officer in charge of Naval Aeronautical Engine Laboratory, Navy Yard, *Washington.*

TOM, J. E., chief engineer, Matthews Engineering Co., *Sandusky, Ohio.*

TOPIE, EDWARD G., lieutenant, Ordnance Dept., Holt Mfg. Co., *Peoria, Ill.*

WATKINS, ROY AVERY, ensign, Bu. of Steam Engineering, Division of Aeronautics, *Washington.*

WHITE, JAMES A., chief engineer, Harrison Radiator Corp., *Lockport, N. Y.*

WIEDERHOLD, OSCAR, JR., electrician, Dodge Brothers, *Philadelphia.*

YOUS, CHARLES R., automobile rebuilding, private shop, 1408 Ridge Ave., *Evanston, Ill.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Sept. 19 and Oct. 15, 1918. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment.

ARTHUR, C. W. (A) special representative, Mitchell Motors Co., *Racine, Wis.*

BOEHME, ERNEST (M) chief inspector, The Dayton Engineering Laboratories Co., *Dayton, Ohio.*

BONHAM, F. A. (A) parts and service manager, Chevrolet Motor Co., 880 West 181st St., *New York City.*

EAGLES, N. W. (M) efficiency engineer, American Car & Foundry Co., 944 Kirby Ave., *Detroit, Mich.*

EISENBERG, SAMUEL B. (J) draftsman, Fulton Motor Truck Co., Farmingdale, Long Island, N. Y., (mail) 325 East 3rd St., *New York City.*

HASKINS, HOWARD B. (S. E.) chief machinist's mate, U. S. Naval Steam Engineering School, Class 17, Stevens Institute, Hoboken, N. J., (mail) 120 Pallister Ave., *Detroit, Mich.*

HAYES, RALPH S. (M) first lieutenant, Quartermaster Corps, 593 State, War & Navy Bldg., *Washington.*

HIRTZEL, CLEMENT HENRY A. (M) major, Royal Air Force & Aircraft Production, Royal Aero Club, *London, England.*

HOYT, G. W. (M) chief engineer, The Oakes Co., Indianapolis, (mail) 3905 Broadway, *Indianapolis.*

ILLINOIS SILO & TRACTOR CO. (Aff.) Representatives: B. F. Sprankle, general manager, J. G. Sinclair, mechanical engineer, *Bloomington, Ill.*

KEAGY, GEORGE H. (A) production engineer, New York Shipbuilding Corp., Camden, N. J., (mail) 823 N. Broad St., *Philadelphia.*

KIMBALL, H. G. (A) patent lawyer, Wetmore & Jemner, 34 Pine St., *New York City.*

LEHR, A. A. (A) purchasing agent and engineer, J. C. Wilson Co., 1333 West Grand Blvd., *Detroit, Mich.*

MACFARLAND, A. F. (M) metallurgist, U. S. Ball Bearing Mfg. Co., Chicago, (mail) 4535 Palmer St., *Chicago.*

NASH, FRED S. (J) aeronautical engineer and designer, Dayton-Wright Airplane Co., (mail) 1423 N. Main St., *Dayton, Ohio.*

RIEMAN, C. S. (A) president and general manager, Elgin Motor Car Corp., *Argo, Ill.*

ROBBINS, WALTER C. (A) motor engineer, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

SCOTT, P. L. (J.) engineer, Humphrey Gas Pump Co., *Syracuse, N. Y.*

SINCLAIR, J. G. (Aff. Rep.) mechanical engineer, Illinois Silo & Tractor Co., *Bloomington, Ill.*

SPRANKLE, B. F. (Aff. Rep.) general manager, Illinois Silo & Tractor Co., *Bloomington, Ill.*

VONACHEN, F. J. (J) second lieutenant, Truck and Tractor Testing, Ordnance Department, Rock Island Arsenal, *Rock Island, Ill.*

Book Reviews *for* S. A. E. Members

This section of THE JOURNAL contains notices of the technical books considered to be of interest to members of the Society. Such books will be described as soon as possible after their receipt, the purpose being to show the general nature of their contents and to give an estimate of their value.

AEROPLANE CONSTRUCTION AND ASSEMBLY. A manual for aviation mechanics. By J. T. King and N. W. Leslie. Published by William Hood Dunwoody, Industrial Institute, Minneapolis. 1918. Cloth, 6 by 9 in., 116 pp.

The purpose of this manual is to give aviation mechanics an essentially practical understanding of the work they are expected to do. It treats of the elementary airplane principles and the points involved in its assembly ready for flight.

It is assumed that an airplane rigger must have a clear conception of the points of heavy strain in the plane. Frequently the machines have no load marks whatever, and the aviation mechanic must naturally use his own judgment in lifting any part of the machine. In lifting the tail post off the ground, to turn a machine around by hand, care must be taken to apply the lift under the *load* points, at intersection points of the fuselage struts with the longerons. Panels are to be lifted at the points where the struts are attached to the wing beams. Were a strain placed on the leading or trailing edges, a permanent distortion would take place in the ribs of the wing; the trailing edge, made of flattened steel tubing in the machine described (Curtiss JN4), would be subjected to permanent flexure, spoiling the efficiency and disturbing the alignment of the machine.

A list of 91 terms is given by way of nomenclature or terminology. Airplane types are defined, as well as terms used to describe assembly operations.

The manner in which the machines are shipped, and should be uncrated, is described.

The common-sense nature of the remarks made is indicated by the following examples of instruction.

The bolts should bear evenly and make a snug fit, and where possible the heads should be on top. Cables are to be examined for kinks and rust. As the struts are under compression they should distribute their loads evenly. If they do not fit perfectly they are liable to split. Insert the bolts in their respective holes; as the cotter-pin holes are drilled on assembly to insure a good fit, each castle nut should be replaced on the bolt from which it was taken.

An experienced pilot must know the amount of pressure he is exerting when turning the rudder; if the control cables are too tight the essential sense of feeling is absent. There should be approximately ¼ in. play in the rudder control cables. Lock the turnbuckles and wrap insulating tape around each pair, starting at the forked end and finishing at the loop of the cable.

Tighten turnbuckles in general until the threads are covered by the barrel of the turnbuckle. This is essential; a turnbuckle with threads showing has not its maximum strength.

There are two general methods of checking the dihedral angle on the planes: (1) the cord method, and (2) the dihedral board method. (1) By stretching a cord from the wing masts along the upper surface of the top plane and measuring the vertical distance from this cord to the plane at definite points along the plane.

Check the angle of incidence under at least three points on the span of the plane. The incidence of the upper plane is correct when the lower plane has been adjusted, due to the fact that all struts and fittings are cut to a very fine degree of accuracy for length and angle.

The stagger should be checked at two points on each panel, where the planes are attached to the engine-section panel and at the outer struts of the planes. The stagger is increased or decreased by adjusting the stagger wires running diagonally between the front and rear struts. They should have equal tension.

Inspection and preparation of the engine before flight are outlined, including instructions as to avoiding air lock in water system, filling radiator not over seven-eighths full and changing oil after 10-12 hours' running. It is stated that an airplane engine must have constant care and attention. Propeller mounting is described in considerable detail, necessary precautions as to taper fit on the crankshaft and correct position for cranking being given.

At the end of a day's flight the propeller should be cleaned thoroughly. Spare propellers must be stored in a place of even temperature, suspended on horizontal pegs, with free air circulation around the blades.

Running an engine with a warped propeller is harmful to it, the crankshaft particularly.

Prior to leaving a machine in a field over night head it directly into the wind, place chocks in front of the wheels, attach a rope to each outer front wing strut and secure each rope to a peg driven in the ground. Fasten the tail in a similar manner, by tieing a rope to the tail-skid post. Lock the controls in neutral position. Cover the engine and propeller with some waterproof material.

The general inspection of an airplane advised, with regard to the tail unit, the engine section, the main planes, and the controls, is indicated by a statement beginning to the effect that starting at the running gear it should be noticed whether all wires are properly tensioned, and their respective turnbuckles and shackles locked. The nuts on the strut socket and plate fittings should be cotter-pinned. The wheel hubs should be well greased and the axle collars fastened securely with hex bolts and castle nuts. Tires inflated to 60 lb. pressure. The streamline covering on the wire wheels should be well doped and securely held on.

Remove the inspection cover of the fuselage. See that all diagonal bracing wires are at proper tension and bound with insulating tape where they cross. All nuts and turnbuckles should be properly locked. Special attention should be given to the control wires, as to their running in a straight line and not fouling any of the internal bracing wires.

Airplane fittings and parts are described and illustrated clearly.

Common faults in rigging are noted, nose heaviness, tail heaviness, right or left wing high, tendency to pull right or left, lack of climbing ability or speed, bowing of wing struts.

The book is concluded with a brief statement of the theory of flight.